CANADA
DEPARTMENT OF MINES
AND
TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 324

GROUND-WATER RESOURCES OF TOWNSHIPS 1 to 6, RANGES 6 to 9, WEST OF PRINCIPAL MERIDIAN, MANITOBA

(Manitou Area)

By
E. C. Halstead

OTTAWA
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PART I

INTRODUCTION

The present report is an attempt to assemble the data on ground-water resources in a form that will be useful to well drillers, farmers, municipal authorities, and others interested in obtaining adequate water supplies.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports that, in Manitoba, cover a square block of sixteen townships lying between the correction lines and beginning at the Saskatchewan boundary. The reports on the most southerly strip of the province include in addition the two townships lying north of the International Boundary. The secretary-treasurer of each municipality will be supplied with the information covering that municipality, and copies of the reports will also be available for study at offices of the Provincial and Federal Departments. Further assistance in interpreting the reports may be obtained by applying to the Chief Geologist, Geological Survey of Canada, Ottawa.

How to Use the Report

Anyone desiring information concerning ground-water in any particular locality will find the available data listed in the well records, and other pertinent information on the maps of the area. For those unfamiliar with these reports it is, perhaps, advisable that that part dealing with the area as a whole be read first, so as to be in a better position to understand the more particular descriptions of each township that follow. Also, the map accompanying the report should prove a useful source of reference when reading the text.

The map consists of two figures. Figure I shows bedrock and surface geology. The water-bearing properties of the bedrock change from formation to formation, and are referred to in subsequent pages. The type of glacial deposit at the surface may be determined from the map, and its possibilities as an aquifer are also discussed in this report.

Figure 2 shows the location and types of wells in the area, the land relief (topography), and the drainage pattern. Not every well is plotted on the map, but most of those giving pertinent information are shown, and probably include 90 per cent of the wells in the area. Where ground water is not readily available, or carries too much dissolved salts to be used, dugouts often form the only means of supply. The topography is shown by contours, or lines of equal elevation, spaced at vertical intervals of 50 feet.

The well records are compiled from data obtained by interviewing farmers, and in many cases their accuracy depends upon the farmer's memory. Wherever possible data were checked by plumb-line measurement to the nearest foot. The wells are tabulated by townships and sections, and the total depth of the well, depths to the water level at high and low stages, and, where possible, the depth at which the water-bearing horizon occurs, are all listed. The general character of the water is stated, and the use to which it can be put. Wells from which samples were taken for analysis are indicated on the well-record sheets. An idea of how much water a well can be expected to yield is suggested by the number of stock (cattle and horses only) that can be watered at it. One head is assumed to consume between 8 and 10 gallons of water a day. Unless followed by the word "only"

the figure for the number of stock watered is not necessarily the maximum yield of the well, but simply the greatest amount that the present user has required. The word "only" indicates that the figure given is the maximum yield of the well. To obtain the position of an aquifer at any given point, the elevation of the point should be determined from the contours on Figure 2 of the map. Elevations of adjacent wells may be found in the well records and the depth to the aquifer can usually be determined from them. By comparing elevations the depth of the aquifer below the unknown point may be estimated. This method is particularly applicable to bedrock wells, but may not be successful where information is too limited, or where the glacial drift is thick and of an irregular character. In such instances a person searching for water should refer to the text for information on the nature of the deposits in that area.

GLOSSARY OF TERMS USED

Alkaline. The term 'alkaline' or 'alkali' water has been applied rather loosely to waters having a peculiar and disagreeable taste, and commonly a laxative effect. The waters so described in the Prairie Provinces are those heavily charged with sulphates of magnesium and sodium (respectively Epsom salts and Glauber's salts) and are more correctly termed sulphate waters. Truly 'alkaline' waters owe that property to the presence of calcium carbonate and calcium bicarbonate. In this report an attempt to adhere to local terminology is made by referring to sulphate waters as 'alkali' in the well records, and the term 'alkaline' is avoided.

Alluvium. Deposits of clay, silt, sand, gravel, and other material in lake beds and in flood plains of modern streams. The term also includes the material in river terraces, which once formed part of the flood plain but are now above it.

Aquifer. A porous bed, lens, pocket, or deposit of material that transmits water in sufficient quantity to satisfy pumping wells and springs.

Bedrock. Bedrock, as here used, refers to partly or wholly consolidated deposits of gravel, sand, silt, clay, and marl that are older than the glacial drift.

Bentonite and bentonitic clays have the property of swelling when water is added to them. They occur as white beds as much as 2 feet thick, but usually much thinner, and are probably formed by the weathering of volcanic ash.

Buried pre-Glacial Stream Channel. A channel eroded into the surface of the bedrock by a stream before the advance of the continental ice-sheet, and subsequently either partly or wholly filled in by sands, gravels, and boulder clay deposited by the ice-sheet or later agencies.

Coal Seam. The same as a coal bed. It is a deposit of carbonaceous material formed from the remains of plants by partial decomposition and burial.

Contour. A line on a map joining points that have the same elevation above sea-level.

Continental Ice-sheet. The great ice-sheet that covered most of the surface of Canada many thousands of years ago.

Escarpment. A cliff or relatively steep slope separating level or gently slopping areas.

Flood Plain. A flat part of a river valley ordinarily above water but submerged when the river is in flood. It is an area where silt and clay are being deposited.

Glacial Drift. A general term that includes all the loose, unconsolidated materials that were deposited by the ice-sheet, or by the waters associated with it. Clay containing boulders usually forms a large part of the glacial drift in an area, and is called glacial till or boulder clay, and is not to be confused with the more general term glacial drift, which occurs in the following several forms:

(1) Terminal Moraine or Moraine. A ridge or series of ridges formed by glacial drift that was laid down at the margin of a moving ice-sheet. The surface is characterized by irregular hills and undrained basins.

(2) Kame Moraine. Assorted deposits of sand and gravel laid down at or close to the ice margin. The topography is similar to that of a terminal moraine.

(3) Ground Moraine. Boulder clay (till) laid down at the base of an ice-sheet. The topography may vary from flat to gently rolling.

(4) Glacial Outwash. Sand and gravel plains or deltas formed by streams that issued from the continental ice-sheet.

(5) Glacial-lake Deposits. Sand, silt, and clay deposited in glacial lakes during the retreat of the ice-sheet.

Shoreline. A discontinuous escarpment, with intervening gravel beaches and bars, which indicates the former margin of a glacial lake.

Ground Water. The water in the zone of saturation below the water-table.

Hydrostatic Pressure. The pressure that causes water in a well to rise above the point at which it was first encountered in the well, namely, at the level of the aquifer.

Impervious or impermeable. Beds such as fine clays or shale are considered to be impermeable when they do not permit the perceptible passage or movement of ground water.

Pervious or Permeable. Beds are pervious or permeable when they permit the perceptible passage or movement of ground water, as in the case of sands and gravels.

Pre-Glacial Land Surface. The surface of the land as it existed before the ice-sheet covered it with drift.

Recent Deposits. Deposits that have been laid down by the agencies of water and wind since the disappearance of the continental ice-sheet; for example, alluvium in stream valleys.

Sand Point or Driven Well. A sand point is a piece of perforated and screened pipe 2 or 3 feet long, which ends in a sharp point. It is fastened to lengths of ordinary pipe and forced down into surface deposits of a sandy or gravelly nature. The depth of such a well rarely exceeds 30 feet.

Unconsolidated Deposits. The mantle or covering of alluvium, pre-glacial soils, and glacial drift consisting of loose, uncemented material that overlies the bedrock.

Variegated. Beds so described show different colours in alternating beds or lenses.

Water-table. The upper limit of the part of the ground saturated with water. This may be near the surface or many feet below it. A water-table is said to be perched when a zone of saturated material is separated from the main water-table below by a zone or zones of unsaturated material.

Water-worked Till. Glacial till or boulder clay that has been subjected to water action, usually near the margins of glacial lakes, so that the fine clay has been washed out and a deposit that may be composed mainly of sand and gravel is left behind.

Wells. The term refers to any hole sunk in the ground by any means for the purpose of obtaining water. If no water is obtained they are referred to as dry holes. Wells yielding water are divided into four classes:

(1) Flowing Artesian Wells. Wells in which the water is under sufficient hydrostatic pressure to flow above the surface of the ground at the well.

(2) Non-flowing Artesian (Sub-artesian) Wells. Wells in which the water is under sufficient hydrostatic pressure to raise it above the level of the aquifer, but not above the level of the ground at the well.

(3) Non-artesian Wells. Wells in which the water does not rise above the water-table or the aquifer.

(4) Intermittent Non-artesian Wells. Wells that are generally dry for a part of each year.

GENERAL DISCUSSION OF GROUND WATER

Almost all the water recovered from beneath the earth's surface for both domestic and industrial uses is meteoric water, that is, water derived from the atmosphere. Most of this water reaches the surface as rain or snow. Part of it is carried off by streams as run-off; part evaporates either directly from the surface and from the upper mantle of soil, or indirectly through transpiration of plants; and the remainder sinks into the ground to be added to the ground-water supplies.

The proportion of the total precipitation that sinks into the ground will depend largely upon the type of soil or surface rock, and on the topography; more water will sink into sand and gravel, for example, than into clay; if, on the other hand, the region is hilly and dissected by numerous streams, more water will be immediately drained from the surface than in a relatively flat area. Light, continued precipitation will furnish more water to the underground supply than brief torrential floods, during which the run-off may be nearly equal to the precipitation. Moisture failing on frozen ground will not usually find its way below the surface, and, therefore, will not materially replenish the ground-water supplies. Light rains falling during the growing season may be wholly absorbed by plants. The quantity of moisture lost through direct evaporation depends largely upon temperature, wind, and humidity. Locally these deposits may become very extensive. The water-bearing properties of alluvial deposits are variable, but, in general, such deposits form favourable aquifers. They are porous, and readily yield a part of their contained water, although in places their porosity may be greatly reduced by the presence of fine silt and clay. This type of deposit may be expected to yield moderate domestic supplies through shallow wells, and larger supplies if ~~the deposits are extensive~~.

In some areas of relatively steep slopes, valleys have been partly filled with sand and gravel, which, in turn, have been covered with impervious clay and silt. These circumstances commonly give rise to artesian conditions in the lower part of the valley.

DISCUSSION OF WATER ANALYSES

Both the kind and quantity of mineral matter dissolved in a natural water depend upon the texture and chemical composition of the rocks with which the water has been in contact. Pollution is caused by contact with organic matter or its decomposition products. Analyses of well waters for mineral content are made by the Department of Health and Public Welfare, Winnipeg, and by the Bureau of Mines, Department of Mines and Resources, Ottawa.

As the ground-water survey of Manitoba progresses an effort is made to secure samples representative of each major aquifer encountered; the purpose of this is to compare the chemical characteristics of waters from the various geological horizons and, thereby, assist in making correlations of the strata in which the waters occur. The mineral content of natural waters is also of interest to the consumers, though the effects of the constituents are usually already apparent. The quantities of the various constituents for which tests are made are given as 'parts per million', which refers to the proportion by weight of each constituent in 1,000,000 parts of water. A salt when dissolved in water separates into two chemical units called 'radicals', and these are expressed as such in the chemical analyses. In one group are included the metallic elements of calcium (Ca), magnesium (Mg), sodium (Na), and iron (Fe), and in the other group are the sulphate (SO_4), chloride (Cl), bicarbonate (HCO_3), carbonate (CO_3), and nitrate (NO_3) radicals. The radicals listed in the analyses tabulated in the second part of this report can be combined to give the actual quantity of the particular salts present in the water, but this is not done here as the radicals alone give enough information to identify the water types. In fact, the sulphate, chloride, and carbonate radicals, plus the hardness, serve to identify a water, and crude field tests on the basis of these constituents were used in some areas to outline more completely zones of the various water types.

The following mineral constituents include all that are commonly found in natural waters in quantities sufficient to have any practical effect on the value of waters for ordinary uses:

<u>Silica</u> (SiO_2) is dissolved in small quantities from almost all rocks. It is not objectionable except in so far as it contributes to the formation of boiler scale.

<u>Iron</u> (Fe) in combination is dissolved from many rocks as well as from iron sulphide deposits with which the water comes in contact. It may also be dissolved from well casings, water pipes, and other fixtures in quantities large enough to be objectionable, but separates as the hydrated oxide upon exposure of the water to the atmosphere. Excessive iron in water causes straining on porcelain or enamelled ware, and renders the water unsuitable for laundry purposes. Water is usually considered not potable if the iron content is more than 0.5 part per million.

<u>Calcium</u> (Ca) in the water comes from mineral particles present in the surface deposits, the chief sources being limestone, gypsum, and dolomite. Fossil shells provide a source of calcium, as does also the decomposition of igneous rocks. The common compounds of calcium are calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$), neither of which have injurious effects on the consumer, but both of which cause hardness.

<u>Magnesium</u>(Mg) is a common constituent of many igneous rocks and, therefore, very prevalent in ground water. Dolomite, a carbonate of calcium and magnesium, is also a source of the element. The sulphate of

magnesia ($MgSO_4$) combines with water to form 'Epsom salts,' and renders the water unwholesome if present in large amounts.

Sodium (Na) is derived from a number of the important rock-forming minerals, so that sodium sulphate and carbonate are very common in ground waters. Sodium sulphate (Na_2SO_4) combines with water to form 'Glauber's salt' and excessive amounts make the water unsuitable for drinking purposes. Sodium carbonate (Na_2CO_3) or 'black alkali' waters are mostly soft, the degree of softness depending upon the ratio of sodium carbonate to the calcium and magnesium salts. Waters containing sodium carbonate in excess of 200 parts per million are unsuitable for irrigation purposes[1]. Sodium sulphate is less harmful.

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[1] "The extreme limit of salts for irrigation is taken to be 70 parts per 100,000, but plants will not tolerate more than 10 to 20 parts per 100,000 of black alkali (alkaline carbonates and bicarbonates)". Frank Dixey, in 'A Practical Handbook of Water Supply', Thos. Murby & Co., 1931, p. 254.

Sulphates (SO_4) referred to in this report are those of calcium, magnesium, and sodium, and have been mentioned above in referring to these radicals. They are also formed by oxidation of iron sulphides, and, hence, it is not uncommon to find iron in sulphate waters. Sulphates cause permanent hardness in water, and injurious boiler scale. Sodium and magnesium sulphates are laxative when present in quantities of more than 900 parts per million. The writers found that acclimatized people could drink water containing as much as 2,000 parts per million of all three of the principal sulphates, but that when all were present in quantities over 1,500 parts per million the water was commonly laxative to those not accustomed to it.

Chloride (Cl) is a constituent of all natural waters and is dissolved in small quantities from rocks. Waters from wells that penetrate brines or salt deposits contain large quantities of chloride, usually as sodium chloride (common salt) and less commonly as calcium chloride and magnesium chloride. Sodium chloride is a characteristic constituent of sewage, and any locally abnormal quantity suggests pollution from this source. However, such abnormal quantities should not, in themselves, be taken as positive proof of pollution in view of the many sources from which chloride may be derived. Chlorides impart a salty taste to water if present much in excess of 500 parts per million. In southwestern Manitoba waters with as much as 3,000 parts per million of chloride are used domestically, though more than 1,500 parts per million is generally considered undesirable. The following figures apply to chlorides: stock will require less salt if the water bears 2,000 parts per million; more than 5,000 parts per million is unfit for human consumption; more than 8,000 parts per million is unfit for horses; more than 9,500 parts per million is too much for cattle; and more than 15,500 parts per million is excessive for sheep. Magnesium chloride, less common than sodium chloride, is very corrosive to metal plumbing.

Nitrates (NO_3) found in ground water are decomposition products of organic materials; they are not harmful in themselves, but they do point to probable pollution. It is recommended that a bacterial test be made on water showing an appreciable nitrate content, if it is to be used for domestic purposes.

Carbonates (CO_3) in water are indicated in the table of analyses as 'alkalinity'. Calcium and magnesium carbonate cause hardness in water, which may be partly removed by boiling. Sodium carbonate causes softness in waters, and is ~~referred to under 'Sodium' above.~~

Bicarbonates (HCO_3). Carbon dioxide dissolved in water renders the insoluble calcium and magnesium carbonates soluble as bicarbonates. The latter are decomposed by boiling the water, which changes them to insoluble carbonates.

Hardness is a condition imparted to waters chiefly by dissolved calcium and magnesium compounds. It here refers to the soap-destroying power of water, that is, to the amount of soap that must first be used to precipitate the above compounds before a lather is produced. The hardness of water in its original state is its total hardness, and is classified as 'permanent hardness' and 'temporary hardness'. Permanent hardness remains after the water has been boiled. It is caused by mineral salts that cannot be removed from solution by boiling, but it can be reduced by treating the water with natural softeners, such as ammonia or sodium carbonate, or with many manufactured softeners. Temporary hardness can be eliminated by boiling, and is due to the presence of bicarbonates of calcium and magnesium. Waters containing large quantities of sodium carbonate and small amounts of calcium and magnesium compounds are soft, but if the latter compounds are present in large quantities the water is hard. The following table[1] may be used to indicate the degree of hardness of a water:

[1] Thresh, J.C., and Beale, J.F.: The Examination of Waters and Water Supplies; London, 1925, p. 21.

Total Hardness

Parts per million	Character
0-50	Very soft
50-100	Moderately soft
100-150	Slightly hard
150-200	Moderately hard
200-300	Hard
300 +	Very hard

The above table gives the generally accepted figures for hardness, but the people of southwestern Manitoba have become accustomed to harder waters, and the following table, based on about 800 field determinations of hardness, by the soap method, is more applicable:

Parts per million	Character
0-100	Very soft
100-150	Soft
150-250	Moderately hard
250-350	Hard
350-500	Very hard
500+	Excessively hard

Waters having a hardness of up to 300 parts per million are commonly used for laundry purposes. In southwestern Manitoba, hardness ranges from less than 50 parts per million to more than 2,500 parts per million.

PART II

TOWNSHIPS 1 TO 6, RANGES 6 TO 9, WEST PRINCIPAL MERIDIAN, MANITOBA

(Manitou Area)

Introduction

This is a preliminary report covering a study of the ground-water resources of tps. 1 to 6, rges. 6 to 9, W. Princ. mer. Well inventory work in the area was done in the field season of 1952. The account and map of the glacial geology were supplied by J. A. Elson.

Physical Features

The most conspicuous physiographic feature is the Manitoba escarpment, known as Pembina Mountains. This escarpment, formed by the more resistant beds of the Cretaceous shale, rises abruptly from the featureless plains of the former glacial Lake Agassiz basin to a drift-covered upland area.

A belt of end moraine, averaging 1½ to 2 miles in width, runs parallel with and west of the escarpment. Its hilly surface is wooded and dotted with undrained depressions. Elsewhere the surface is uneven to rolling and is the expression of the irregular bedrock surface mantled with a thin cover of overburden. A major feature of the upland area is Pembina Valley, which is steep sided and terraced. Pembina River, the small stream following the valley, is a remnant of an ancestral stream that carried melt waters from retreating glaciers.

East of the escarpment the surface irregularities were modified by the waters of the former glacial lake and the deposition of silts and clays. A featureless plain sloping east, and inconspicuous beach ridges, were left after the Lake drained.

Geology

Table of Formations

Age	Formation	Character	Thickness (feet)
Recent	Alluvium	Stream-laid mud, silt, sand, and gravel	
Pleistocene	Glacial drift	Till, clay, boulders; assorted sand and gravel in outwash plains and eskers	0-100
Upper Cretaceous	Riding Mountain	Upper beds of medium to light grey, hard, siliceous shale (Odanah shale), with some thin layers of fine, blue sand and bentonite beds; lower beds of slippery clay shale that tend to slump	500 ±
	Vermilion River	Dark grey and black shale, comprising three members:	
		Pembina (dark shale; numerous bentonite bands near base);	80 ±
		Boyne (grey, calcareous shale; non-calcareous dark shale near base);	140 ±
		Morden (calcareous speckled shale overlying dark grey, non-calcareous, blocky shale with thin partings of white sand	190 ±

Upper Cretaceous shales of the Riding Mountain formation underlie the upland area west of the Manitoba escarpment. Although considered to be about 1,000 feet thick, only the lower 300 feet or so of these flat lying beds are present in this area. As seen in outcrops south of Manitou and along creeks tributary to Pembina River, it consists of hard, siliceous grey shale with a slight greenish cast when dry. Commonly, softer bentonitic shale is interbedded with the hard shale and the lower 50 feet or less comprises soft, somewhat waxy, greenish-grey bentonitic shale that tends to slump. These lower beds are the Millwood beds of Tovell.[1]

Sections of the underlying Vermilion River formation are exposed in the valley of Pembina River and in valleys that cut into the Manitoba escarpment. Pembina, Boyne and Morden beds comprise the Vermilion River formation but owing to the fact that the lower beds of the overlying Riding Mountain formation slump easily, the Pembina beds are not well exposed. The Morden beds consist mostly of dark grey, non-calcareous shale. The Boyne beds are mainly medium grey, calcareous, speckled shale with some non-calcareous dark grey shale. Both Morden and Boyne beds contain little bentonite whereas bentonite is characteristic of the uppermost or Pembina beds.

For further information on the bedrock geology including formations older than the Vermilion River, the reader is referred to the report by Wickenden.[2]

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1. Tovell, W. M. : Geology of the Pembina Valley - Deadhorse Creek Area; Preliminary Report 47-7; Province of Manitoba Department of Mines and Natural Resources, Mines Branch, 1951.

2. Wickenden, R. T. D. : Mesozoic Stratigraphy of the Eastern Plains, Manitoba and Saskatchewan; Geol. Surv. Canada, Mem. 239, 1945.

The Manitou area contains two principal types of surface deposits: (1) deposits of glacial Lake Agassiz northeast of the Manitoba escarpment (Pembina Mountains); and (2) deposits of glacial origin on the upland southwest of the Manitoba escarpment. Pembina Valley, which trends sinuously across the south part of the upland from La Riviere to the south half of tp. 1, rge. 6, contains alluvial deposits on several terraces.

The upland occupies over three-quarters of the Manitou area and there the principal deposit is ground moraine forming a layer of sandy-silty till from less than 1 inch to about 40 feet thick. The till overlies the hard siliceous Odanah shale that forms the cores of most hills; the till is thin or absent on some hill-tops. There are several eskers in the ground-moraine area; most of them are low features composed of shaly pebble gravel and poorly sorted sand. A few of them provide satisfactory road metal and all are prospects for supplies of potable ground-water. A belt of end moraine, a broad hummocky ridge of sandy till, extends south from tp. 6, rge. 8, through the central part of the map-area to tp. 2, rge, 7 and thence southeast to the southeast corner of the map-area. This end moraine marks the farthest advance of a lobe of ice from the north and northeast; west of it and underneath it the till is older and was deposited by ice moving from the northwest. The end moraine in tp. 1, rges. 6 and 7, is a different type from that of the long belt just described, and consists of a series of northeast trending ridges with a relief ranging between 8 and 20 feet. These ridges represent a series of small end moraines composed of sandy till. Outwash deposits bordering the long belt of end moraine are located in tp. 1, rge. 6, west of Darlingford, and in the vicinity of Cardinal and Notre Dame de Lourdes. In the last location the outwash contains a large amount of shale gravel but in the south it is composed of silt and clay with only small amounts of sand and gravel. About half-way between Darlingford and Altamont the deposits

of a small lake formed when the ice blocked an eastward flowing drainage system cover the glacial deposits. Next to the moraine the lake deposits are sand but away from the moraine to the west clay and silt predominate. A shallow lake occupied this basin until recently. On the west side of the map-area, in tps. 1 to 4, rge. 9, some areas of clayey silt may be of eolian or outwash origin. This silt is from 1 foot to 5 feet thick and overlies ground moraine.

Pembina Valley contains three distinct types of alluvium, two of which form terraces near the top of the sides of the valley and the third forms the lowest terraces and the flood plain. It has not been possible to show separately the two higher alluvia on a small-scale map. The lower of the two high alluvia forms paired terraces that are well developed on both sides of the valley at heights ranging from 30 to 120 feet above the present river level; these terraces are best developed in and downstream from tp. 1, rge. 8. This alluvium is poorly sorted, sandy, shale-pebble gravel and is 60 or more feet thick. It was deposited during a rise in the level of early glacial Lake Agassiz. The highest alluvium is found on broad terraces in the wide parts of the valley in and downstream from tp. 2, rge. 9. It consists of pebble and cobble gravel that is predominantly shale and should be a good aquifer. This coarse alluvium may be of outwash origin. The lowest alluvium, forming the flood plain of the river, is a poorly sorted sandy silt with local lenses and pockets of sand and gravel.

The northeast corner of the map-area is underlain by lake deposits of medium to fine sand and silt. These deposits increase in thickness eastward from the Manitoba escarpment and are from 50 to 100 feet thick near Graysville. South of township 5 most of the lake deposits below an altitude of 1,050 feet are silt. About 40 per cent of the lake deposits just east of the Manitoba escarpment are buried under a layer of alluvium in the form of alluvial fans built from streams that undergo an abrupt change from a steep to a gentle gradient in

crossing from the escarpment to the plain. The alluvium is sandy-silty clay and at most localities the lake sands or silts are only a few feet below the surface. Alluvium also covers large parts of the wave-cut terraces. These deposits of water-worked drift, mostly a lag concentrate of boulders, overlie till or bedrock over small areas. Areas of bedrock without the veneers of boulders also are included as water-worked drift. Locally the alluvium also covers beach bars. These are ridges of medium to coarse sand and fine gravel up to 300 feet wide and 6 feet high. At an altitude of about 1,050 feet along the base of the scarp extending from Miami to Rosedale one bar is from 15 to 20 feet thick and locally contains good road metal. East of Thornhill beach bars are numerous but only a few were mapped. Though generally thin, some bars are good aquifers and many are sources of road metal.

Water Supply

Aquifers within the Riding Mountain formation offer the best possibilities for the development of ground water in the upland area west of the Manitoba escarpment. Sufficient precipitation as rain or snow-melt penetrates the overburden to recharge with potable water all aquifers within the top 100 feet of the bedrock. This water can be obtained from inexpensive dug wells in those areas where the thickness of overburden is 20 feet or less. Elsewhere bored or drilled wells to bedrock aquifers will yield sufficient water for farm and domestic needs.

Dug wells that penetrate one or more lenses of sand or gravel within the overburden in the upland area will yield at least 10 to 15 gallons of water per minute. A well dug in till without penetrating sand or gravel must be from 4 to 6 feet in diamenter to provide enough wall area for infiltration and storage space for the water between periods of pumping.

Outwash deposits associated with the belt of end moraine extending from Notre Dame de Lourdes to the International Boundary through Darlingford

carry excellent aquifers. Sands deposited, as beaches and bars, that mark the shorelines of glacial Lake Agassiz are also excellent aquifers, from which water can be obtained by installing sandpoints or inexpensive dug wells.

The lake silts and clays east of the escarpment yield very little water. Here only the upper 25 feet or less are permeable; therefore, if no water enters a test hole above this depth, it is advisable to abandon the hole.

Township 1, Range 6. Pembina River crosses the southwest quarter of the township in a valley that is more than a mile wide and up to 300 feet deep. Elsewhere the surface is rolling to uneven with wooded areas.

The maximum thickness of the overburden is 30 feet and it consists of end moraine, outwash, minor ice-contact stratified deposits, and of coarse, alluvium in the valley bottom. Discontinuous lenses of sand and gravel within these deposits yield water. The yield is commonly sufficient for 20 head of stock and the water, although alkali, is potable.

If test holes fail to penetrate aquifers within the overburden, they should be continued into the bedrock for a supply of hard, potable water is usually encountered at the contact of the bedrock and the overburden or in the fractures of the Odanah beds just below the contact. A third aquifer is present at a greater depth in the Millwood beds that underlie the Odanah beds. This aquifer was encountered in two wells, one in SE. $\frac{1}{4}$ sec. 1, bored 46 feet, and the other in SW. $\frac{1}{4}$ sec. 3, bored 83 feet. A sample of water from the Millwood aquifer analysed by the Duro Pumps and Softeners Co. Ltd., London, Ontario, has a total hardness of 363 parts per million, of which 170 parts per million was sodium.

Township 1, Range 7. Pembina River in its broad, deep valley makes an arc in the northern part of the township. Elsewhere the surface is uneven to rolling and is dissected by intermittent streams. End moraine, in places more than 80 feet deep, mantles the bedrock. Other surficial deposits are of only minor importance.

Bored wells are common and reach depths of 60 to 180 feet. Discontinuous lenses of sand or gravel within the overburden are water-bearing. Where these lenses are not encountered, wells are bored into the bedrock.

The water is hard and commonly alkali. It is, however, used for both domestic and stock uses. In the southwest quarter of the township softer water is reported. The water was never found to have a pressure head of more than 15 feet in these wells measured.

Township 1, Range 6. Pembina River flows east through the central part of the township in a broad terraced valley that is, in places, more than 3 miles wide. Ground moraine, as much as 60 feet deep, mantles the bedrock in the township except on the terraces, which are covered with alluvium.

Wells are dug or bored an average of 40 feet. Lenses of sand or gravel on or within the ground moraine are common aquifers yielding hard, alkali water. A supply sufficient for 20 to 30 head of stock can be obtained from deeper wells that reach the fractured zones near the surface of the bedrock. At Mowbray wells are dug 15 to 30 feet into the overburden to supply domestic needs.

In NE.$\frac{1}{4}$ and SE.$\frac{1}{4}$ sec. 34, wells are drilled 130 and 125 feet deep respectively. Soft water that does not rise more than 90 feet from the surface of the ground was encountered. The quality of the water, the low hydrostatic pressure, and the elevation of the bottoms of the wells suggest that the aquifer encountered is in the Millwood beds of the Riding Mountain formation.

Township 1, Range 9. Pembina River crosses the northeast quarter of the township in a wide terraced valley. Ground moraine, 4 to more than 40 feet thick, mantles the bedrock except on the terraces that are covered with recent alluvium.

Wells penetrating the ground moraine reach lenses of sand or gravel that are water bearing and commonly yield alkali water. The supply is sufficient but limited as the lenses are discontinuous and the ground moraine has low permeability.

Bored wells 40 to 100 feet deep obtain a supply of relatively soft water from the contact of the overburden and bedrock or within the top 60 feet of the bedrock. The deepest wells are drilled in NE.$\frac{1}{4}$ sec. 3, SE.$\frac{1}{4}$ sec. 10, NE.$\frac{1}{4}$ sec. 14, and SW.$\frac{1}{4}$ sec. 19 to depths of 180, 230, 158, and 138 feet respectively. The water of the deeper wells is soft and the aquifer encountered may be the Millwood beds of the Riding Mountain formation.

At Snowflake, wells are dug 15 to 30 feet into the ground moraine. One well, 127 feet deep, drilled at the Snowflake Hotel penetrated 57 feet of till, 7 feet of boulders, and then shale to the bottom of the well where water entered and rose to a point 27 feet from the surface of the ground.

Township 2, Range 6. The rolling surface of the township is dissected by intermittent and branching Dead Horse Creek. The overburden consists of ground moraine that varies in thickness from 8 to 30 feet. Lake Agassiz covered the northeast quarter of the township and built up beach ridges of sand and gravel.

A sufficient supply of hard clear water is obtained from shallow wells dug into the overburden. Some wells, less than 10 feet, are entirely in beach deposits of Lake Agassiz. Two or more wells are common on each farm and where the supply is limited, especially in summer months, the practice is to dig additional wells or build dug-outs.

Township 2, Range 7. The surface of the township is rolling

to uneven and dissected by channels of intermittent creeks. The overburden varies in thickness from 15 to 100 feet and is not a good aquifer. Wells that are dug or bored less than 50 feet encounter lenses of sand or gravel that commonly yield hard, alkali water.

Wells 178 and 168 feet deep, in SE.$\frac{1}{4}$ sec. 14 and SW.$\frac{1}{4}$ sec. 23 respectively, reach a common aquifer. This yields soft water that is under sufficient hydrostatic pressure to rise to a point 20 feet from the surface of the ground. Soft water also was encountered in wells drilled 220 feet and 110 feet deep in SE.$\frac{1}{4}$ sec. 17 and SE.$\frac{1}{4}$ sec. 34, respectively, but the supply is limited to approximately 15 gallons a day.

In section 24 two wells were drilled; one, in SW.$\frac{1}{4}$, is 110 feet deep, the other, in SE.$\frac{1}{4}$, is 70 feet deep. Both wells obtain water from the upper fractured 10 feet of the bedrock. A third hole, drilled in NE.$\frac{1}{4}$ of the same section, reached bedrock at 45 feet and drilling operations continued to a depth of 290 feet before the hole was abandoned as dry.

Township 2, Range 8. The uneven surface is broken by linear hills in the west half of the township. The overburden varies in thickness from 8 feet on the tops of the hills to more than 50 feet in sections 17 and 22 where test holes drilled 54 and 89 feet, respectively, penetrated 50 feet of 'blue clay', probably ground moraine.

Where the overburden is less than 20 feet thick, wells are dug either to lenses of sand or gravel or to the upper fractured zones of the bedrock. The water, commonly hard and alkali, is usually sufficient for 25 to 30 head of stock.

In NE.$\frac{1}{4}$ sec. 13, sec. 18, SE.$\frac{1}{4}$ sec. 24, SW.$\frac{1}{4}$ sec. 30, and NW.$\frac{1}{4}$ sec. 35, wells are drilled 150, 99, 140, 100, and 85 feet respectively, to aquifers in the bedrock. Those in SW.$\frac{1}{4}$ sec. 18 and SW.$\frac{1}{4}$ sec. 30 yield soft water.

Township 2, Range 9. Pembina River flows south across the east half of the township in a valley that in places is more than 2 miles wide and 250 feet deep. Elsewhere the surface of the township is rolling to uneven.

Thin deposits of outwash silts mantle the ground moraine west of the river but are unimportant as sources of water. Ground moraine varies in thickness from 10 to 30 feet but its aquifers yield only limited supplies of water, More abundant supplies are obtained from the underlying bedrock. One such aquifer is common to sections 16, 17, 19, 20, 28, and 29. Wells in these sections, ranging in depth from 45 to 66 feet, yield a potable water sufficient for domestic and stock needs.

Springs localized at the contact of the Odanah and Millwood beds are present along the side of the west half of the valley.

Township 3, Range 6. Manitoba escarpment trends north-northwest to south-southeast across the central part of this township. Ground moraine mantles the bedrock west of the escarpment, modified drift and lake deposits occur along its flanks, and lake and alluvial silts occur below it. The modified drift represents till that has been worked over by the glacial lake waters with the removal of the fines and consequent concentration of the boulders.

An abundant supply of water is commonly obtained from beach deposits and local pockets of gravel and sand deposited by waters of Lake Agassiz. Wells in these deposits are less than 15 feet deep and commonly supply abundant water, but many such aquifers freeze during winter months and hence may fail at that time.

Elsewhere wells are dug in the overburden and a supply is obtained that is commonly sufficient provided stock supply is augmented by surface waters collected in dugouts.

In SE.$\frac{1}{4}$ sec. 34 two dugouts were made to collect surface run-off for a stock supply when dug test holes failed to reach an aquifer. Salty water was encountered in a well 300 feet deep in SE.$\frac{1}{4}$ sec. 24. In SW.$\frac{1}{4}$ sec. 18, a well 92 feet deep penetrated 'blue clay' to an aquifer at that depth, which yields sufficient water for 60 head of stock.

Township 3, Range 7. Except for some outwash sand and silt

in the southwest corner of the township, the bedrock is mantled by ground moraine and a broken ridge of end moraine trending north-south through the town of Darlingford.

There is a good supply of ground water in this township but it is generally unsuited for domestic purposes. The chief aquifers are reached by dug or bored wells 15 to 50 feet deep. Ground water percolating through the overburden dissolves alkali salts that give the water a disagreeable taste. Shallow wells along the intermittent stream channels commonly yield potable water.

Drilled wells vary in depth from 45 to 148 feet. In NE.$\frac{1}{4}$ sec. 14 and NE.$\frac{1}{4}$ sec. 17 wells drilled 52 and 45 feet deep, respectively, reached a water-bearing gravel in which the water was under sufficient pressure to rise to a point 14 feet from the surface of the ground. Water was also encountered in sand at a depth of 115 feet in a well drilled 138 feet deep in NW.$\frac{1}{4}$ sec. 18. In NW.$\frac{1}{4}$ sec. 17 a well drilled 72 feet reached a water-bearing zone of boulders at a depth of 60 feet. Other drilled wells reach aquifers in the bedrock at depths of 117 to 138 feet.

Township 3, Range 8. The surface of the township is rolling to uneven. Ground moraine averaging 3 to 25 feet in thickness mantles the bedrock. It is overlain in a few areas in the south half of the township by outwash silts.

A supply of hard to moderately soft water is obtained from aquifers in the upper fractured zones of the bedrock. These aquifers are generally reached within feet of the surface. Two or more wells are common on each farm. Drilled wells are found in sections 1, 2, 3, and 15, which reach aquifers at depths of 80, 65, 120, and 90 feet respectively.

Township 3, Range 9. Pembina River crosses the southeast quarter of the township in a broad valley approximately 230 feet deep. Ground moraine 4 to 35 feet thick overlies the bedrock. This is in part overlain by outwash gravels and silts.

Wells 20 to 45 feet deep reach aquifers in the bedrock that yield potable ground water of sufficient quantity on most farms to supply 50 or more head of stock.

Drilled wells are not common. In SE.$\frac{1}{4}$ sec. 6, a well drilled 187 feet reaches an aquifer in which soft alkaline water is under sufficient pressure to rise to a point 12 feet from the surface of the ground. In SW.$\frac{1}{4}$ sec. 8, a well drilled 116 feet reaches an aquifer that yields hard water containing much iron. In NW.$\frac{1}{4}$ sec. 7 and NE.$\frac{1}{4}$ sec. 10, wells drilled 93 and 80 feet deep, respectively, yield hard, alkali water sufficient for 40 head of stock.

Township 4, Range 6. Glacial Lake Agassiz covered most of the township and left beaches of sand and gravel that are excellent aquifers. Elsewhere lake clays and silts are poor aquifers and hence dugouts are needed on each farm to collect and store the surface run-off to supply water for stock. Wells are dug 15 to 35 feet into the lake clays but the water pumped from them is salty or alkali.

No wells have been drilled to the bedrock. An aquifer of potable water may be encountered below the lake clays but there have been no drilling operations to substantiate this assumption.

Township 4, Range 7. The overburden along the western side of the township is till, representing end moraine, except for a thin deposit of silt in the southwestern part that was laid down in a glacial lake. Between this end moraine and the top of the escarpment that crosses the northeast corner of the area is a band of ground moraine. Along the escarpment Cretaceous shales are exposed, in part covered by a mantle of water-worked till. Below the escarpment in the extreme northeast corner of the township the surface deposits are alluvial sands and gravel.

The overburden varies in thickness from 6 to 35 feet but most wells are dug into the bedrock where hard, clear slightly alkali water is encountered. An ample supply is available. Each farm has one or more wells.

Township 4, Range 8. Ground moraine that varies in thickness from 5 to 50 feet overlies the bedrock. Its surface is irregular to rolling.

Most of the aquifers are in the overburden. They are reached by dug wells 15 to 50 feet deep, which commonly bottom on the bedrock. Here the ground water that has percolated downward through the overburden is moving laterally along and within its bottom few feet. Deeper wells drilled to depths of 90, 150, and 100 feet in sections 11, 14, and 27 respectively, reach aquifers in the bedrock that yield soft water.

Township 4, Range 9. The surface of the township is rolling to uneven, wooded, with an intermittent creek flowing southwest across the south half. Ground moraine that averages approximately 25 feet in thickness mantles the bedrock except in the southwest corner of the township where it is overlain by thin deposits of clayey silt, at depths of 20 to 25 feet either in the overburden or in the upper fractured layers of the bedrock. In NW.$\frac{1}{4}$ sec. 21, one well was drilled 122 feet to an aquifer that yields soft water, whereas two other wells bored 60 and 80 feet deep yield hard alkali water.

Township 5, Range 6. The surface of the township is generally flat and slopes to the east. It is crossed by an intermittent creek, Tobacco Creek. The overburden consists of glacial till overlain by sand, gravel, and clay that was deposited during the existence of former Lake Agassiz, which completely covered the township. Beaches of the former lake in the southwest quarter are excellent aquifers. At Miami a beach deposit supplies water for the town from an aquifer less than 20 feet from the surface of the ground. Except for the aquifers in the beach sands and gravels, wells dug into the lake deposits to depths of less than 50 feet commonly yield alkali water.

On those sections where shallow wells have failed dugouts or drilled wells have been made. Notable among these are two test holes drilled in 1943, on NE.$\frac{1}{4}$ sec. 14. One drilled 211 feet supplied 2 imperial gallons per minute from an aquifer of coarse sand encountered

at a depth of 159 to 162 feet. The other, drilled 140 feet, pumped 18 imperial gallons per minute from an aquifer of coarse sand at a depth of 129 to 130 feet. The static water level in the well was 28 feet 7 inches and pumping at 18 imperial gallons per minute showed a stablized water level at 60 feet below the surface. The capacity of the well is approximately $\frac{1}{2}$ imperial gallon per minute for 1 foot of drawdown.

Wells drilled in sections 10 and 11 are 115 and 100 feet deep respectively. The aquifer encountered, which lies at a depth of approximately 108 feet, is a layer of gravel overlain by an impervious layer of lake sediments. In the deeper well the water rises to the ground surface but does not overflow, whereas in the 100-foot well the water rises to a point 2 feet from the surface of the ground. A well drilled 200 feet deep in SE.$\frac{1}{4}$ sec. 31 yields soft water.

Township 5, Range 7. The Manitoba escarpment crosses the township from section 2 to section 32. East of the escarpment the surface is flat and slopes gently eastward. The original drift surface has been modified by waters of glacial Lake Agassiz. Ground water, of sufficient quantity for domestic and stock needs is pumped from aquifers at depths of 15 to 54 feet. The water is hard and commonly has a concentration of sulphates.

West of the escarpment the surface is irregular and wooded. Streams cut the mantle of till overlying the bedrock. Wells are from 18 to 50 feet deep and obtain water from aquifers in the bedrock.

Drilled wells are not common. One, in NE.$\frac{1}{4}$ sec. 9, was drilled 70 feet and penetrated 'blue clay'. The water, which rises to a point 55 feet from the surface of the ground, is hard and contains much iron. In SW.$\frac{1}{4}$ sec. 21, two test holes were abandoned, one was drilled 180 feet and the other bored 60 feet.

Township 5, Range 8. The surface of the township is hilly to uneven. Ground moraine 5 to 25 feet thick mantles the bedrock except for a belt of end moraine that trends northwest from section 1 to

section 33. Surface run-off from the end moraine follows intermittent shallow channels that in places fill closed depressions to form sloughs.

Ground moraine yields only small supplies of water, but locally lenses of stratified sand and gravel within it yield water freely. As the ground moraine is widely distributed, it is an important source of ground water. At most places it will yield sufficient water from inexpensive dug wells for domestic and stock needs.

Outwash sand and gravel and ice-contact stratified drift deposited above and beside the end moraine are excellent aquifers. If wells fail to encounter sufficient water within the overburden, then deeper wells should be bored or drilled to the bedrock where a sufficient supply is commonly encountered in its upper fractured surface.

Township 5, Range 9. The surface of the township is rolling to hilly and the overburden consists of ground moraine that varies in thickness from 15 to more than 50 feet.

A supply of hard water is obtained from inexpensive dug wells that penetrate the overburden. The aquifers are local in extent and consist of lenses of sand and gravel. Glacio-fluvial or outwash deposits of sand and gravel found along abandoned or intermittent stream courses are excellent aquifers. South and west of Somerset, wells penetrate sand at depths of less than 20 feet and yield a supply of potable water. Wells that reach the bedrock yield hard water that is commonly sufficient for domestic and stock needs. Twenty-nine of the 76 wells recorded in this township obtain water from the bedrock.

Township 6, Range 6. The surface of the township is a featureless plain sloping to the east. Boyne River enters the township in section 24, and follows a shallow trench cut into sediments deposited in glacial Lake Agassiz.

Two aquifers are present. The upper one is fine sand and silt which lies within 20 feet of the surface. It yields hard, clear water sufficient for domestic use and can be reached by inexpensive dug wells.

The second aquifer is sand and gravel lying in depressions on the surface of the till and overlain by some 90 feet or more of compact impervious blue clay and by the upper 20 feet of sand and silt. The depression fillings or pockets of sand and gravel are reached by wells drilled to depths of 105 and 272 feet. The supply of water is not abundant as is evidenced by the excessive drawdown during the pumping of each well. An interval of 3 to 4 hours is required for complete recovery of the water level in the well. Fine sand tends to plug the casing and limit the supply. As the supply is variable from such aquifers at depths of 100 feet or more, it is recommended that shallow wells be dug for domestic use and where such supplies are limited dugouts may be built to collect run-off for stock use.

Township 6, Range 7. The Manitoba escarpment trends southeast across the township from section 31 to section 4. East of the escarpment the surface, modified by waters of glacial Lake Agassiz, is flat and slopes to the east. Ground moraine mantles the bedrock west of the escarpment in the southwest corner of the township.

An abundant supply of hard, clear water is obtained to the east of the escarpment by digging wells less than 20 feet deep into the sandy surface deposits. In seasons of less than normal rainfall it may be necessary to build dugouts for a stock supply.

West of the escarpment water is obtained from sand and gravel lenses in the ground moraine. Wells reaching depths of less than 40 feet yield sufficient water for domestic and stock needs.

Township 6, Range 8. Boyne River crosses the township in a narrow valley in places more than 100 feet deep, cut into bedrock. Elsewhere the surface is uneven to hilly. End moraine is the most prevalent surface deposit. There are also some areas of ground moraine, glacio-fluvial and outwash deposits.

South of Boyne River wells are dug into the overburden and commonly bottom on bedrock where a supply of potable water is obtained. North of the river where the overburden is thicker wells are dug 30 to

50 feet deep and commonly penetrate sand and gravel lenses in the drift.

In NE.$\frac{1}{4}$ sec. 26, a well drilled 108 feet penetrated glacial till to a zone of gravel where hard water was encountered under sufficient pressure to rise to within 33 feet of the surface of the ground.

Township 6, Range 9. The surface of the township is hilly to uneven. There are some slough lands and intermittent streams. Ground moraine covers most of the township and consists of a sandy-silty till. The thickness of the overburden varies from an average of 5 feet in section 12, to 26 feet in section 18, but nowhere is it more than 40 feet.

In digging a well there are two potential aquifers. The first may be encountered in the overburden where glacio-fluvial deposits may be present as discontinuous lenses of sand and gravel. These aquifers will yield enough water for 20 to 25 head of stock. The water is hard with a concentration of sulphate salts.

The second aquifer may be encountered on reaching the bedrock. Here the downward percolating ground water moves along the contact of the bedrock and overburden. This water is commonly fresh and of sufficient quantity for domestic uses and 50 head of stock. Wells tapping these aquifers average 35 feet in depth.

The possibilities of a supply at greater depth in the bedrock are unknown, but at greater depth it is not uncommon to encounter softer water.

Sample Number	ANALYSES OF GROUND WATERS FROM Tps. 1 to 6, Rges. 6 to 9, West Principal meridian, Manitoba																					
									Hardness (as $CaCO_3$) (parts per million)			Constituents as analysed (parts per million)										
	¼ section	Section	Township	Range	Meridian	Depth of well (feet)	Aquifer[x]	Conductance (Micromhos 25°C)	Carbonate	Noncarbonate	Total	Alkalinity (as $CaCO_3$)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Silica (SiO_2)	Ammonia (NH_4)
1	NE	8	3	6	1st	20	t	4951	780.0	1,689.5	2,469.5	780.0	301.6	417.1	439.8	951.6	2166.1	164.6		184.0	28.0	trace
2	SW	8	5	6	1st	16	s	2513	658.4	721.7	1,380.1	658.4	443.7	66.2	66.0	803.2	327.6	167.4		310.0	26.5	
3	SE	23	6	6	1st	272	s	9129	65.2	2154.5	2,219.7	65.2	596.6	177.4	1132.0	79.5	1625.8	2226.1		17.0	15.7	
4	NE	8	3	7	1st	43	t	1102	377.4	199.2	576.6	377.4	163.2	41.1	11.7	460.4	93.8	92.2		14.0	20.5	
5	SW	21	5	8	1st	17		1350	474.2	0.0	474.2	498.8	109.1	49.0	156.2	608.5	262.1	11.6		24.0	27.5	
6	NE	6	1	9	1st	35	g	3432	494.4	120.4	614.8	494.4	156.4	54.5	558.2	603.2	579.8	488.8		80.0	24.2	
7	NE	19	5	9	1st	17	t	2846	229.2	890.1	1,119.3	229.2	342.7	64.1	152.4	279.6	305.7	516.2		256.0	28.0	

x - Symbols used for aquifers: t - Pleistocene till
s - " sand
g - " gravel

Discussion of Analyses

A general discussion of water analyses will be found on page 5 of this report.

No standards for the chemical composition of potable waters have been established in Canada. In the United States, however, the need for federal control of the quality of water used by interstate water carriers led to the establishment by the American Public Health Service of the following partial list of chemical standards.

Chemical constituent	Maximum concentration permitted (parts per million)	
Dissolved solids	500	(1,000 permitted if necessary)
Chloride	250	
Sulphate	250	
Magnesium	125	
Fluoride	1.5	
Iron and manganese	0.3	

The presence of nitrate in ground water may indicate organic contamination. It is recommended that water containing more than 45 parts per million of nitrate should not be used in feeding infants because of the danger of infant cyanosis (methemoglobinemia) resulting in the so-called blue baby.

Sample No. 3 was taken from a drilled well that obtains water from an aquifer of fine sand below Lake Agassiz sediments. The water is very hard with a concentration of the constituents sodium, sulphate, and chloride. These constituents contribute to the salty taste of the water.

All the samples are hard water but samples Nos. 1 and 7, from Thornhill and Somerset, respectively, are excessively hard. Samples Nos. 4 and 5, from Darlingford and Altamont, respectively, may be regarded as average examples of ground waters from the overburden. Although hard water it can be softened by commercial softeners and detergents.

Sample No. 2, from a well in Miami, is hard water with a concentration of calcium and bicarbonate. This sample, taken from an outwash plain of sand and gravel, is not representative of ground waters percolating through such deposits. Analyses commonly show smaller concentrations of the constituents listed and the water is softer.

Record of Wells

The following table of well records has been prepared from driller's records and data collected by the Geological Survey of Canada. The following abbreviations are used:

Sec.	—	Section
Drl.	—	Drilled well
Brd.	—	Bored well
V.R.	—	Vermilion River formation
R.M.	—	Riding Mountain formation
Dom.	—	Domestic use
Stk.	—	Stock use
Not	—	Not used
Mun.	—	Municipal use
#	—	Well from which a sample was taken

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 1, Range 6

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Dug	1,455	46	16	16	V.R.	Hard	Dom. Stk.	Sufficient for 20 head
3	SW	Brd.	1,483	83	30	-	V.R.	Hard	Dom. Stk.	" " 25 "
4	NE	Dug	1,505	33	24	33	-	Hard	Dom. Stk.	" " 20 "
7	NE	Dug	1,178	16	-	-	Drift	Hard	Dom. Stk.	Supply not sufficient.
8	NE	Brd.	1,505	48	27	27	V.R.	Soft	Dom. Stk.	Sufficient for 40 head.
9	NW	Brd.	1,504	55	10	20	V.R.	Hard	Dom. Stk.	" " 35 "
10	SW	Brd.	1,482	30	18	12	R.M.	Hard	Dom. Stk.	" " 20 "
11	SW	Drl.	1,487	31	9	10	V.R.	Hard	Dom. Stk.	" " 37 "
12	SW	Brd.	1,469	55	15	16	V.R.	Hard	Dom. Stk.	" " 25 "
13	SW	Dug	1,450	20	14	20	V.R.	Hard	Dom. Stk.	" " 10 "
14	NW	Brd.	1,473	23	13	12	V.R.	Hard	Dom. Stk.	" " 18 "
15	SE	Dug	1,466	24	7	-	-	Hard	Dom. Stk.	" " 35 "
16	NE	Dug	1,488	14	8	8	R.M.	Hard	Dom. Stk.	Three other wells on farm
17	SW	Dug	1,503	20	16	-	Drift	Hard	Dom. Stk.	Sufficient for 20 head
18	NE	Dug	1,492	31	21	-	Drift	Hard	Dom. Stk.	" " 21 "
19	NE	Dug	1,483	24	19	-	-	Hard	S. & R.	- - -
20	SE	Brd.	1,487	60	20	20	V.R.	Hard	Dom. Stk.	Sufficient for 30 head
21	SE	Dug	1,504	24	20	10	V.R.	Hard	Dom. Stk.	" " 40 head
22	SW	Dug	1,483	13	9	10	V.R.	Hard	Dom. Stk.	" " 40 "
24	NE	Dug	1,448	21	18	21	R.M.	Hard	Dom. Stk.	Alkali water
25	NE	Dug	1,410	26	13	26	-	Hard	Dom. Stk.	Sufficient for 30 head
26	SE	Dug	1,467	26	8	14	R.M.	Hard	Dom. Stk.	" " 20 "
27	SW	Dug	1,457	35	32	35	-	Hard	Dom. Stk.	Not sufficient during winter months
28	SE	Dug	1,472	38	14	-	-	Hard	Dom. Stk.	Sufficient for 16 head
29	NE	Drl.	1,499	40	20	-	R.M.	Hard	Dom. Stk.	Also a well 26 ft. deep
30	SW	Dug	1,502	27	9	27	-	Hard	Dom. Stk.	Sufficient for 20 head
31	NW	Brd.	1,500	57	30	20	R.M.	Hard	Dom. Stk.	" " 25 "
32	SW	Dug	1,474	27	9	-	-	Hard	Dom. Stk.	" " 10 "
33	SW	Dug	1,488	14	9	13	R.M.	Hard	Dom. Stk.	" " 18 "

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 1, Range 7

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SW	Brd.	1,539	90	40	50	V.R.	Hard	Dom. Stk.	Sufficient for 25 head
2	SE	Brd.	1,539	115	35	100	V.R.	Hard	Dom. Stk.	" " 18 "
3	NE	Brd.	1,542	120	100	-	-	Hard	Dom. Stk.	" " 15 "
4	NE	Brd.	1,552	65	20	-	-	Hard	Dom. Stk.	- - -
5	SE	Drl.	1,547	92	13	-	V.R.	Soft	Dom. Stk.	- - -
6	NW	Dug	1,578	20	6	-	Drift	Hard	Not	Alkali water
7	NE	Brd.	1,571	180	120	-	-	Hard	Stk.	Alkali water with much iron.
8	SW	Brd.	1,546	170	70	-	-	Hard	Dom. Stk.	Sufficient supply
9	SW	Brd.	1,559	57	15	40	R.M.	Hard	Dom. Stk.	Sufficient for 20 head
10	NE	Brd.	1,526	55	30	40	V.R.	Hard	Dom. Stk.	" " 30 "
11	SW	Brd.	1,541	63	38	60	V.R.	Hard	Dom. Stk.	" " 35 "
15	NW	Brd.	1,539	80	49	-	V.R.	Hard	Dom. Stk.	" " 30 "
16	SE	Brd.	1,549	95	25	-	Gravel	Hard	Dom. Stk.	Water in gravel at 50ft.
18	SE	Dug	1,569	20	6	10	R.M.	Hard	Dom.	- - -
20	NE	Brd.	1,549	125	90	20	V.R.	Hard	Dom. Stk.	Sufficient for 80 head
21	NW	Brd.	1,534	120	60	80	V.R.	Hard	Dom. Stk.	" " 40 "
24	SE	Brd.	1,486	60	30	-	-	Hard	Dom. Stk.	Sufficient for 25 head
25	SE	Brd.	1,504	67	13	30	V.R.	Hard	Stk.	Also a well bored 40 ft.
28	SW	Dug	1,526	6	4	-	Gravel	Hard	Dom. Stk.	- - -
29	SE	Brd.	1,540	47	23	-	-	Hard	Dom. Stk.	Sufficient for 15 head
32	NE	Dug	1,272	10	4	-	-	Hard	Dom. Stk.	- - -
36	NW	Dug	1,493	14	5	14	V.R.	Hard	Dom. Stk.	- - -
36	NE	Dug	1,492	30	15	-	V.R.	Hard	Stk.	Also a house well 20 ft. deep

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 1, Range 8

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NW	Brd.	1,581	27	15	-	-	Hard	Dom. Stk.	Also a well 32 ft. deep
2	NE	Brd.	1,563	50	20	30	V.R.	Hard	Dom. Stk.	Sufficient for 30 head
3	SW	Brd.	1,536	60	20	-	-	Soft	Dom. Stk.	" " 20 "
4	NW	Brd.	1,542	75	35	35	V.R.	Hard	Dom. Stk.	Also a well 50 ft. deep
5	NE	Dug	1,547	25	9	-	-	Hard	Dom. Stk.	Sufficient for 15 head
6	NW	Dug	1,547	35	15	10	V.R.	Hard	Dom. Stk.	" " 25 "
7	SW	Brd.	1,553	24	9	14	V.R.	Soft	Dom. Stk.	" " 40 "
8	SW	Brd.	1,550	100	30	-	V.R.	Hard	Dom. Stk.	" " 24 "
9	SE	Dug	1,544	71	60	-	V.R.	Hard	Dom. Stk.	- - -
10	SE	Dug	1,524	31	14	-	-	Hard	Dom. Stk.	- - -
11	SW	Dug	1,405	50	31	-	-	Hard	Stk.	- - -
13	SW	Brd.	1,361	80	25	3	V.R.	Soft	Dom. Stk.	" " 35 "
14	SW	Brd.	1,387	30	28	3	V.R.	Hard	Dom. Stk.	" " 30 "
18	NW	Dug	1,314	18	16	-	Sand	Hard	Dom. Stk.	Also a well 24 ft. deep
22	NW	Brd.	1,234	38	22	5	V.R.	Hard	Dom. Stk.	Also a well 25 ft. deep
23	SW	Brd.	1,404	60	30	2	V.R.	Hard	Dom. Stk.	Sufficient for 30 head
25	NW	Drl.	1,548	60	30	-	Gravel	Hard	Dom. Stk.	" " 17 head
27	SE	Dug	1,311	30	-	5	V.R.	Hard	Dom. Stk.	Well was dry at time of interview
28	NW	Dug	1,540	20	5	-	-	Hard	Dom. Stk.	Also a well 25 ft. deep
29	NE	Dug	1,557	30	10	-	-	Hard	Dom. Stk.	Sufficient for 25 head
30	SE	Brd.	1,294	40	20	2	V.R.	Hard	Dom. Stk.	" " 22 "
31	NW	Dug	1,565	35	17	12	V.R.	Hard	Dom.	Stock well 35 ft. deep
31	NE	Dug	1,550	34	15	15	V.R.	Hard	Dom.	Stock well drilled 90 feet.
32	SE	Brd.	1,574	28	25	5	V.R.	Soft	Dom.	Stock well 29 ft. deep
34	SE	Drl.	1,554	125	92	-	V.R.	Hard	Dom. Stk.	Sufficient for 25 head
35	SW	Brd.	1,575	20	10	-	-	Hard	Dom.	Also a well 26 ft. deep
36	SW	Drl.	1,548	65	20	-	-	Hard	Dom. Stk.	Sufficient for 50 head

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 1, Range 9

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Dug	1,554	40	10	-	Till	Hard	Dom. Stk.	Sufficient for 20 head
2	NW	Brd.	1,534	38	20	-	Till	Hard	Dom. Stk.	" " 35 "
3	NE	Drl.	1,530	180	-	-	-	Soft	Dom. Stk.	" " 40 "
4	NW	Dug	1,530	30	20	-	Gravel	Hard	Dom. Stk.	- - -
5	NW	Dug	1,542	28	-	-	Gravel	Hard	Dom. Stk.	Sufficient for 30 head
6	NE	Dug	1,545	35	25	-	Gravel	Hard	Dom. Stk.	" " 15 "
7	NW	Brd.	1,559	30	20	-	R.M.	Hard	Dom. Stk.	" " 30 "
8	NE	Brd.	1,545	50	40	35	R.M.	Hard	Dom. Stk.	Also a well 32 ft. deep
9	SW	Dug	1,517	30	15	-	-	Hard	Dom. Stk.	Sufficient for 15 head
10	SE	Drl.	1,541	230	50	-	-	Soft	Dom. Stk.	" " 50 "
11	NW	Brd.	1,527	40	28	-	-	Hard	Dom. Stk.	" " 30 "
12	SW	Brd.	1,516	88	38	-	R.M.	Hard	Dom. Stk.	" " 20 "
13	SE	Brd.	1,549	38	-	10	R.M.	Hard	-	School well
14	NW	Brd.	1,546	90	80	76	R.M.	Hard	Dom. Stk.	Sufficient for 20 head
15	SW	Brd.	1,544	40	30	-	-	Hard	Dom. Stk.	- - -
16	SW	Dug	1,543	26	21	21	R.M.	Hard	Dom. Stk.	Also a well 36 ft. deep
17	NE	Drl.	1,553	40	-	-	-	Hard	Dom. Stk.	Sufficient for 15 head
19	SW	Drl.	1,552	138	-	-	R.M.	Soft	Dom. Stk.	- - -
20	SW	Brd.	1,556	53	33	-	-	Hard	Dom. Stk.	Sufficient for 15 head
21	NE	Dug	1,559	22	16	-	Till	Hard	Dom. Stk.	" " 15 "
22	NW	Brd.	1,547	23	15	-	-	Hard	Dom. Stk.	- - -
26	NE	Drl.	1,263	25	15	-	Gravel	Hard	Dom.	Also a stock well 30 ft. deep
29	SW	Brd.	1,546	20	15	20	-	Hard	Dom. Stk.	- - -
30	NE	Brd.	1,607	66	16	-	-	Hard	Dom. Stk.	- - -
31	SE	Drl.	1,617	110	20	-	-	Soft	Dom. Stk.	Sufficient for 30 head
32	SE	Dug	1,589	31	13	-	-	Hard	Stk.	" " 20 "
33	NE	Dug	1,332	47	37	-	-	Hard	Dom. Stk.	- - -
34	NE	Dug	1,270	35	29	-	Gravel	Hard	Dom.	- - -

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 2, Range 6

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SW	Dug	1,351	12	10	-	-	Hard	Dom. Stk.	- - -
2	NE	Dug	1,367	20	10	15	V.R.	Hard	Dom. Stk.	Sufficient for 40 head
3	NW	Dug	1,410	11	6	-	-	Hard	Stk.	Also a well 30 ft. deep
4	SE	Dug	1,454	20	5	10	V.R.	Hard	Dom. Stk.	- - -
5	NE	Dug	1,482	20	10	-	Till	Hard	Stk.	Sufficient for 20 head
6	NW	Dug	1,495	11	4	-	Till	Hard	Dom. Stk.	Sufficient for 40 head
8	SE	Dug	1,471	28	12	-	-	Hard	Dom. Stk.	" " 30 "
9	NW	Dug	1,409	27	23	27	-	Hard	Dom. Stk.	" " 30 "
10	NE	Dug	1,295	8	5	8	-	Hard	Dom.	- - -
11	SE	Dug	1,331	28	19	-	Till	Hard	Dom. Stk.	Sufficient for 20 head
12	NW	Dug	1,286	30	29	-	Till	Hard	Stk.	" " 15 "
13	SE	Dug	1,174	9	4	-	Gravel	Soft	Dom. Stk.	" " 35 "
16	NE	Dug	1,405	30	22	-	-	Hard	Dom. Stk.	" " 30 "
17	SE	Dug	1,400	15	6	-	Sand	Hard	Dom.	Well at school
18	NW	Dug	1,457	44	34	-	-	Hard	Dom. Stk.	Sufficient for 25 head
19	NE	Dug	1,406	16	12	-	-	Hard	Dom. Stk.	" " 15 "
20	NW	Dug	1,384	18	16	18	-	Hard	-	- - -
21	SE	Dug	1,311	16	14	16	-	Hard	Stk.	Sufficient for 40 head
22	SW	Dug	1,297	11	6	-	Till	Hard	Dom. Stk.	Two other wells
23	NE	Dug	1,213	12	10	-	Sand	Hard	Dom. Stk.	Sufficient for 30 head
24	SE	Dug	1,165	15	12	-	Gravel	Hard	Dom. Stk.	" " 30 "
25	SW	Dug	1,164	22	11	-	Sand	Hard	Dom. Stk.	" " 30 "
26	NW	Dug	1,360	18	12	-	Sand	Hard	Dom.	Two other wells
28	SW	Dug	1,308	12	8	-	Sand	Hard	Stk.	Sufficient for 30 head
30	SE	Dug	1,386	11	2	-	Sand	Hard	Dom. Stk.	" " 60 "
31	NW	Dug	1,394	28	22	-	Gravel	Hard	Dom. Stk.	" " 10 "
32	SW	Dug	1,350	12	6	-	Till	Hard	Dom. Stk.	" " 20 "
33	NW	Dug	1,323	12	10	-	Sand	Hard	Dom.	Also a well 28 ft. deep
36	SE	Dug	1,111	14	8	14	-	Hard	Dom. Stk.	Sufficient for 25 head

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 2, Range 7

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Dug	1,505	28	23	–	–	Hard	Dom. Stk.	Sufficient supply
2	NE	Dug	1,519	20	12	–	Till	Hard	Dom. Stk.	Sufficient for 30 head
3	NE	Drl.	1,523	65	–	–	–	Hard	Dom. Stk.	Not sufficient for 20 head
9	SE	Brd.	1,523	56	28	–	Gravel	Hard	Dom. Stk.	Also a well 23 ft. deep
10	NW	Dug	1,555	45	40	–	Till	Hard	Dom. Stk.	Sufficient for 40 head
11	SW	Dug	1,536	45	10	–	–	Hard	Dom. Stk.	Sufficient for 20 head
12	NE	Dug	1,486	16	11	–	Sand	Hard	Dom. Stk.	" " 30 "
13	NE	Dug	1,475	13	10	–	Sand	Hard	Dom. Stk.	" " 20 "
14	SE	Drl.	1,492	178	12	–	V.R.	Hard	Dom. Stk.	Sufficient supply
15	SW	Brd.	1,534	45	18	–	Gravel	Hard	Dom. Stk.	Sufficient for 70 head
16	NW	Dug	1,529	30	10	–	Gravel	Hard	Dom. Stk.	" " 25 "
17	SE	Drl.	1,569	220	70	–	V.R.	Soft	Dom. Stk.	Also a bored well 60 ft. deep
20	NW	Drl.	1,552	140	120	30	V.R.	Hard	Dom. Stk.	" " well 40 ft. deep
21	NW	Dug	1,520	25	13	–	–	Hard	Dom.	Also a well for stock
22	SE	Dug	1,486	36	26	–	Till	Hard	Dom. Stk.	Sufficient for 30 head
23	SW	Drl.	1,489	168	24	103	V.R.	Hard	Stk.	Also a house well dug 14 ft. deep
24	NE	Brd.	1,422	46	27	–	Till	Hard	Stk.	Sufficient for 25 head
25	NE	Dug	1,450	26	17	–	Gravel	Hard	Dom. Stk.	" " 15 "
26	SE	Dug	1,436	37	14	–	Till	Hard	Stk.	" " 40 "
27	NW	Dug	1,489	35	17	33	R.M.	Hard	Dom. Stk.	" " 30 "
28	SW	Dug	1,529	17	13	–	Drift	Hard	Dom.	Also a stock well 25 ft. deep
30	NW	Dug	1,558	25	24	–	Gravel	Hard	Dom. Stk.	Sufficient for 15 head
33	SW	Brd.	1,531	40	15	–	–	Hard	Dom. Stk.	– – –
34	SE	Drl.	1,473	110	–	–	–	Soft	Dom.	Also a stock well 30 ft. deep
35	SE	Drl.	1,454	79	–	–	Drift	Hard	Dom. Stk.	Sufficient for 20 head
36	NE	Dug	1,422	26	13	–	Drift	Hard	Dom.	Also a stock well 78 ft. deep

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 2, Range 8

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
2	NE	Brd.	1,546	16	14	-	Drift	Hard	Dom.	Also a stock well 50 ft. deep
4	SE	Dug	1,572	61	25	15	R.M.	Hard	Dom. Stk.	Sufficient for 30 head
5	NE	Dug	1,582	29	22	-	-	Hard	Dom. Stk.	" " 60 "
6	SW	Dug	1,553	20	12	9	R.M.	Hard	Dom.	Also a stock well 20 ft. deep
7	NW	Brd.	1,586	30	25	-	-	Hard	Dom. Stk.	Sufficient for 15 head
9	SW	Dug	1,582	25	17	-	-	Hard	Dom. Stk.	" " 40 "
10	NW	Dug	1,578	32	12	-	-	Hard	Dom. Stk.	" " 30 "
13	NE	Drl.	1,550	150	25	-	-	Hard	Dom. Stk.	" " 20 "
14	SE	Brd.	1,545	37	20	-	-	Hard	Dom.	Also a stock well
15	NE	Brd.	1,566	55	25	-	-	Hard	Dom. Stk.	Also a well 30 ft. deep
16	NW	Dug	1,578	30	15	8	R.M.	Hard	Dom. Stk.	Also another well 30 ft. deep
17	SE	Dug	1,592	54	30	-	Drift	Hard	Dom. Stk.	Sufficient for 50 head
18	SW	Drl.	1,588	99	59	72	V.R.	Soft	Dom. Stk.	" " 40 "
19	NW	Dug	1,558	35	15	-	-	Hard	Dom. Stk.	Also a drilled well
20	NE	Dug	1,582	19	14	10	R.M.	Hard	Dom. Stk.	Sufficient for 40 head
21	NW	Dug	1,590	20	10	5	R.M.	Hard	Dom. Stk.	Also a well 15 ft. deep
22	SW	Brd.	1,568	80	20	-	R.M.	Soft	Dom. Stk.	Sufficient for 20 head
23	SE	Brd.	1,563	100	60	-	R.M.	Hard	Dom. Stk.	Also a bored well 40 ft. deep
24	SE	Drl.	1,516	140	136	20	R.M.	Soft	Dom. Stk.	Sufficient for 45 head
26	SW	Brd.	1,571	42	22	-	R.M.	Hard	Dom. Stk.	Also a dug well 15 ft. deep
27	SE	Dug	1,572	26	15	-	-	Hard	Dom. Stk.	Sufficient for 25 head
29	NE	Dug	1,587	32	22	-	R.M.	Soft	Not	- - -
30	SW	Drl.	1,561	100	30	5	R.M.	Soft	Dom. Stk.	Also a drilled well 130 ft. deep
32	NE	Dug	1,594	23	12	6	R.M.	Hard	Dom. Stk.	Also a well 17 ft. deep
33	NW	Dug	1,593	20	10	-	-	Hard	Dom. Stk.	Also a well 22 ft. deep
35	NW	Drl.	1,583	85	20	13	R.M.	Hard	Dom. Stk.	Also a well 45 ft. deep
36	NW	Brd.	1,568	60	20	-	-	Hard	Dom. Stk.	Sufficient for 40 head

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 2, Range 9

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Dug	1,588	21	13	-	-	Hard	Stk.	Sufficient for 60 head
2	NE	Dug	1,423	26	6	20	R.M.	Hard	Dom. Stk.	" " 40 "
3	SW	Dug	1,321	13	8	-	-	Hard	Dom. Stk.	Sufficient supply
4	NW	Brd.	1,569	90	50	30	V.R.	Hard	Dom. Stk.	Sufficient for 30 head
5	SW	Drl.	1,572	144	16	-	V.R.	Soft	Dom. Stk.	" " 45 "
6	SW	Dug	1,562	21	9	-	-	Hard	Dom. Stk.	" " 70 "
10	NW	Dug	1,308	8	7	-	-	Hard	Dom. Stk.	- - -
11	SE	Dug	1,433	60	35	-	-	Hard	Not	Also a drilled well 85 ft. deep
12	NE	Dug	1,579	13	8	6	V.R.	Soft	Dom. Stk.	Sufficient for 25 head
15	NE	Brd.	1,473	76	-	-	-	Soft	Dom. Stk.	" " 35 "
16	NW	Dug	1,549	65	62	20	V.R.	Hard	Dom. Stk.	" " 20 "
17	SW	Brd.	1,561	66	-	-	-	Hard	Dom. Stk.	" " 40 "
18	NW	Dug	1,600	38	12	-	R.M.	Hard	Dom. Stk.	" " 30 "
19	SE	Dug	1,573	25	13	-	Gravel	Soft	Dom. Stk.	" " 30 "
20	SE	Drl.	1,551	47	44	-	-	Hard	Dom.	School well
20	NE	Dug	1,550	52	26	-	-	Hard	Dom. Stk.	Sufficient for 45 head
21	SW	Dug	1,552	51	34	-	-	Hard	Dom. Stk.	" " 15 "
22	NW	Dug	1,543	35	20	33	R.M.	Hard	Stk.	Domestic well bored 45 ft.deep
25	NE	Drl.	1,555	108	26	-	-	Hard	Dom. Stk.	- - -
28	NW	Dug	1,550	22	15	-	-	Hard	Dom. Stk.	Sufficient for 50 head
29	SE	Dug	1,549	45	15	-	-	Hard	Dom. Stk.	" " 50 "
31	SE	Brd.	1,554	26	12	-	Drift	Hard	Dom. Stk.	Dugout for stock
32	NW	Dug	1,563	45	30	40	R.M.	Hard	Dom. Stk.	Sufficient for 30 head
32	SE	Dug	1,560	30	12	-	Drift	Hard	Dom. Stk.	Also a drilled well 150 ft. deep
36	NE	Dug	1,552	60	30	-	R.M.	Hard	Dom. Stk.	Sufficient for 60 head

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 3, Range 6

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
2	NW	Dug	1,184	20	12	-	Sand	Hard	Dom. Stk.	Sufficient for 60 head
3	NW	Dug	1,232	6	3	-	Sand	Hard	-	Lake Agassiz beach sand
4	NE	Dug	1,283	40	30	-	Drift	Hard	Dom. Stk.	Not sufficient for 20 head
5	SW	Dug	1,343	30	15	-	Drift	Hard	Dom. Stk.	Dugout for stock
6	NW	Brd.	1,374	38	-	-	Sand	Hard	Dom. Stk.	Sufficient for 25 head
7	NW	Dug	1,348	14	10	-	Gravel	Hard	Stk.	Also a dugout
10	NE	Dug	1,174	14	8	-	Sand	Hard	Dom. Stk.	Four dug wells on farm
11	NE	Dug	1,128	8	2	-	-	Soft	Dom. Stk.	- - -
12	NE	Dug	1,033	12	10	-	Sand	Hard	Dom.	- - -
13	SE	Dug	1,030	14	8	-	Sand	Hard	Dom. Stk.	Supply not sufficient in winter
14	SW	Dug	1,140	8	4	-	Sand	Hard	Dom. Stk.	Sufficient for 50 head
15	NE	Dug	1,139	40	38	-	Sand	Hard	Dom. Stk.	" " 40 "
16	SW	Dug	1,278	22	20	-	-	Hard	Dom. Stk.	Dugout for stock
17	NE	Dug	1,295	38	36	-	Drift	Hard	Dom. Stk.	Dugout for stock
18	SW	Drl.	1,364	92	-	-	Drift	Hard	Dom. Stk.	Sufficient for 60 head
19	SW	Dug	1,372	12	4	-	Gravel	Hard	Dom.	Dugout for stock
21	SW	Dug	1,273	12	8	-	Drift	Hard	Dom. Stk.	Sufficient for 20 head
22	NE	Drl.	1,097	80	60	-	-	Hard	-	Too salty for drinking water
24	SE	Drl.	1,005	300	-	-	Drift	-	Not	Alkali water
24	NE	Dug	993	12	8	-	Sand	Hard	Dom.	Two other wells
25	NE	Dug	985	20	16	-	Drift	Hard	Stk.	Not sufficient
26	NW	Dug	1,040	7	4	-	Sand	Hard	Dom. Stk.	Dugout for stock
29	SW	Dug	1,515	24	14	-	-	Hard	Dom.	- - -
32	SE	Dug	1,175	14	6	-	-	Hard	Stk.	- - -
35	SW	Dug	1,025	11	10	-	Sand	Hard	-	Also a dugout
36	SW	Dug	993	30	24	-	Sand	Hard	Dom.	Also a well dug 40 ft. deep

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 3, Range 7

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NW	Dug	1,425	43	17	-	-	Hard	Dom. Stk.	Alkali water
2	NE	Dug	1,432	35	10	-	Sand	Hard	Dom. Stk.	Sufficient for 15 head
3	NW	Dug	1,500	18	13	-	-	Hard	Dom. Stk.	Also a drilled well
5	SE	Brd.	1,553	50	35	-	Drift	Hard	Dom. Stk.	Sufficient for 30 head
8	SW	Dug	1,591	43	18	-	Gravel	Hard	Dom. Stk.	- - -
9	NW	Dug	1,541	27	18	-	Drift	Soft	Dom. Stk.	Sufficient for 50 head
10	SW	Brd.	1,500	32	12	-	Drift	Hard	Stk.	- - -
11	SW	Dug	1,439	18	14	-	Sand	Hard	Dom. Stk.	Sufficient for 40 head
12	SE	Dug	1,379	10	5	-	Sand	Hard	Dom. Stk.	" " 45 "
13	SW	Drl.	1,385	26	14	-	Drift	Hard	Dom. Stk.	" " 15 "
14	SE	Drl.	1,409	43	10	-	Drift	Hard	Dom. Stk.	" " 40 "
15	SE	Brd.	1,454	35	26	-	Drift	Hard	Dom. Stk.	Also a bored well 43 ft. deep
16	SE	Dug	1,509	25	9	-	-	Hard	Dom. Stk.	Sufficient for 20 head
17	SW	Drl.	1,591	66	41	-	Drift	Hard	Dom. Stk.	Also a dug well 50 ft. deep
18	NW	Dug	1,551	19	9	-	-	Hard	Dom. Stk.	Sufficient for 50 head
20	NE	Dug	1,553	19	7	-	Drift	Hard	Dom. Stk.	" " 30 "
22	SE	Dug	1,466	35	15	-	-	Hard	Stk.	- - -
23	NW	Brd.	1,445	45	30	-	-	Hard	Stk.	Sufficient for 70 head
24	SE	Dug	1,379	12	6	-	Drift	Hard	Dom. Stk.	- - -
25	SE	Dug	1,394	118	30	25	V.R.	Hard	Dom. Stk.	Sufficient for 30 head
26	SW	Brd.	1,446	37	25	-	Drift	Hard	Dom. Stk.	" " 20 "
27	NW	Brd.	1,487	44	25	2	V.R.	Hard	Dom. Stk.	" " 20 "
28	SE	Dug	1,501	34	18	32	V.R.	Hard	Dom. Stk.	" " 25 "
29	NW	Brd.	1,606	46	25	-	-	Hard	Dom. Stk.	" " 20 "
30	SE	Dug	1,618	20	15	8	V.R.	Hard	Dom.	Also a dug well 30 ft. deep
31	SE	Dug	1,618	40	25	10	V.R.	Hard	Dom. Stk.	" " " " 23 ft. "
32	SE	Brd.	1,604	40	25	-	-	Hard	Dom. Stk.	Sufficient for 35 head
34	SE	Brd.	1,457	35	25	25	V.R.	Hard	Dom.	Also a stock well 30 ft. deep
35	SW	Brd.	1,448	40	20	-	V.R.	Hard	Dom. Stk.	- - -

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 3, Range 8

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Drl.	1,567	65	30	20	R.M.	Hard	Dom. Stk.	Also a well dug 24 feet
2	SW	Drl.	1,578	65	18	30	R.M.	Hard	Dom. Stk.	Sufficient for 40 head
3	NW	Dug	1,586	120	105	40	R.M.	Hard	Dom. Stk.	Also a bored well 60 ft. deep
4	NW	Dug	1,586	38	32	5	R.M.	Hard	Dom. Stk.	- - -
5	SE	Dug	1,594	34	10	-	R.M.	Hard	Dom. Stk.	Also a well 32 ft. deep
6	SE	Brd.	1,569	32	16	3	R.M.	Hard	Stk.	Also a house well 10 ft. deep
7	SW	Dug	1,589	50	15	10	R.M.	Hard	Dom.	Also a stock well 24 ft. deep
8	NE	Dug	1,588	35	5	20	R.M.	Hard	Dom. Stk.	Sufficient for 15 head
9	NE	Dug	1,616	21	15	12	R.M.	Hard	Dom. Stk.	" " 20 "
10	NW	Dug	1,596	12	8	-	-	Hard	Dom. Stk.	" " 30 "
11	NE	Dug	1,585	28	14	25	R.M.	Hard	Dom. Stk.	Sufficient for 30 head
12	NW	Brd.	1,570	65	10	20	R.M.	Hard	Dom. Stk.	" " 50 "
15	NE	Drl.	1,593	90	-	-	-	Hard	Dom.	Also a well 23 ft. deep
16	NW	Dug	1,618	38	30	-	-	Hard	Dom. Stk.	Also a well 20 ft. deep
17	NW	Dug	1,601	27	19	-	-	Hard	Dom.	- - -
18	NE	Dug	1,597	24	16	12	R.M.	Hard	Dom.	Stock well 61 ft. deep
19	SE	Dug	1,583	30	19	-	-	Hard	Dom. Stk.	Sufficient for 25 head
20	SW	Dug	1,601	30	20	-	-	Hard	Dom.	Stock well 25 ft. deep
21	SW	Dug	1,619	25	17	4	R.M.	Hard	Dom. Stk.	Sufficient for 32 head
23	NW	Dug	1,563	20	12	-	-	Hard	Dom. Stk.	" " 50 "
24	NE	Dug	1,580	39	14	-	-	Hard	Dom. Stk.	" " 30 "
25	SW	Dug	1,571	36	11	-	-	Hard	Dom. Stk.	- - -
26	NE	Brd.	1,633	18	9	-	-	Hard	Dom.	School well
27	NE	Brd.	1,595	30	20	12	R.M.	Hard	Dom.	Also a stock well 27 ft. deep
29	NW	Dug	1,595	20	14	-	-	Hard	Dom. Stk.	Also a well 34 ft. deep
30	NW	Dug	1,611	35	20	-	R.M.	Hard	Dom. Stk.	Sufficient for 25 head
31	SW	Dug	1,616	20	18	-	R.M.	Hard	Dom.	Also a stock well 20 ft. deep
32	SW	Dug	1,590	19	10	7	R.M.	Hard	Dom. Stk.	- - -
33	SW	Brd.	1,595	45	12	-	R.M.	Hard	Stk.	Also a house well 40 ft. deep
35	SW	Dug	1,613	24	12	8	R.M.	Soft	Dom. Stk.	Sufficient for 80 head

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 3, Range 9

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Dug	1,547	30	20	-	-	Hard	Dom. Stk.	Sufficient for 40 head
2	SE	Dug	1,543	40	25	-	-	Hard	Dom. Stk.	- - -
4	SW	Dug	1,512	17	4	-	-	Hard	Dom. Stk.	Sufficient for 70 head
6	SE	Drl.	1,564	187	12	-	R.M.	Soft	Dom. Stk.	" " 60 "
7	SW	Dug	1,532	48	15	-	R.M.	Hard	Dom. Stk.	" " 40 "
8	SW	Drl.	1,537	116	100	-	R.M.	Hard	Dom. Stk.	" " 20 "
10	NE	Drl.	1,549	80	-	-	R.M.	Hard	Dom. Stk.	" " 40 "
12	SE	Dug	1,542	30	20	-	-	Hard	Dom. Stk.	Also a drilled well 75 ft. deep
13	SE	Brd.	1,593	64	17	35	R.M.	Hard	Dom. Stk.	Sufficient for 25 head
14	SE	Dug	1,598	50	30	-	R.M.	Hard	Dom. Stk.	" " 35 "
15	SE	Dug	1,567	26	12	-	-	Hard	Dom. Stk.	Also a bored well 50 ft. deep
16	SE	Brd.	1,550	28	5	-	-	Hard	Dom. Stk.	- - -
18	SW	Dug	1,544	16	13	-	-	Hard	Dom. Stk.	- - -
19	SW	Dug	1,301	19	16	-	-	Hard	Dom.	- - -
20	NW	Brd.	1,523	26	10	-	R.M.	Hard	Dom. Stk.	Sufficient for 15 head
22	SE	Dug	1,593	25	15	4	R.M.	Soft	Dom. Stk.	Sufficient for 60 head
23	SW	Dug	1,594	28	16	-	R.M.	Hard	Dom. Stk.	" " 40 "
24	SE	Dug	1,583	32	15	-	-	Hard	Dom. Stk.	" " 50 "
25	SE	Dug	1,599	18	8	-	-	Hard	Dom. Stk.	" " 20 "
26	SE	Dug	1,591	35	20	-	-	Hard	Dom. Stk.	" " 40 "
27	NE	Brd.	1,601	60	20	-	-	Hard	Dom. Stk.	Sufficient for 20 head
28	SE	Dug	1,599	30	20	2	R.M.	Hard	Dom.	Also a drilled well 120 feet
29	NE	Dug	1,558	21	8	8	R.M.	Hard	Dom. Stk.	- - -
30	SE	Brd.	1,524	90	45	-	-	Hard	Dom.	Dugout for stock
31	SE	Brd.	1,517	48	37	4	R.M.	Hard	Dom.	- - -
33	NW	Dug	1,576	27	16	5	R.M.	Hard	Dom.	- - -
34	SE	Dug	1,596	29	23	-	-	Hard	Dom.	- - -
35	NE	Brd.	1,603	32	16	12	R.M.	Hard	Dom. Stk.	Also a well 44 ft. deep
36	NW	Dug	1,600	40	8	3	R.M.	Soft	Dom. Stk.	Sufficient for 20 head

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 4, Range 6

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Dug	965	11	9	-	Drift	Hard	Dom.	Also a stock well 11 ft. deep
3	SE	Dug	1,014	13	5	-	Sand	Hard	Dom. Stk.	Sufficient for 50 head
4	SE	Dug	1,068	20	18	-	Drift	Hard	Stk.	Also a house well 20 ft. deep
5	SE	Dug	1,111	26	14	-	-	Hard	Stk.	Water is alkali
6	SW	Dug	1,339	18	2	-	Drift	Hard	Dom. Stk.	Also a dugout
8	SE	Dug	1,096	12	7	-	-	Hard	Dom. Stk.	- - -
9	NW	Dug	1,088	18	16	-	Drift	Hard	-	Two dugouts for stock
10	SE	Dug	1,005	10	-	-	Drift	Hard	Dom. Stk.	Alkali water
11	NW	Dug	999	12	9	-	Drift	Hard	Stk.	Sufficient for 20 head
13	SE	Dug	958	8	6	-	Gravel	Hard	Dom.	- - -
15	NW	Dug	984	11	-	-	Gravel	Hard	Dom. Stk.	- - -
16	SW	Dug	1,064	10	7	-	Drift	Hard	Dom. Stk.	Sufficient for 50 head
17	SW	Brd.	1,132	20	8	-	Drift	Hard	Stk.	Alkali water
18	NE	Drl.	1,137	32	28	-	Drift	Hard	Dom. Stk.	Sufficient for 30 head
19	NE	Dug	1,086	16	13	-	Drift	Hard	Stk.	- - -
20	SE	Dug	1,070	18	12	-	-	Hard	Stk.	Alkali water
21	NW	Dug	1,054	19	15	-	Sand	Hard	Dom. Stk.	Sufficient for 20 head
22	SE	Dug	987	11	6	-	Gravel	Hard	Dom. Stk.	Sufficient for 12 head
23	NW	Dug	966	22	17	-	Drift	Hard	Not	Also a dugout
27	NW	Dug	1,003	16	10	-	-	Hard	Dom. Stk.	Sufficient for 20 head
28	NE	Dug	1,011	14	11	-	Gravel	Hard	Dom. Stk.	" " 35 "
29	SW	Dug	1,072	25	17	-	Drift	Hard	Dom. Stk.	" " 30 "
30	NE	Dug	1,075	37	27	-	Drift	Hard	Stk.	- - -
31	NE	Brd.	1,067	80	-	-	Drift	Hard	Stk.	Alkali water
32	SW	Dug	1,036	12	10	-	Sand	Hard	Stk.	Sufficient for 30 head
33	SW	Dug	1,018	14	13	-	Drift	Hard	Dom. Stk.	- - -
34	SW	Dug	982	12	5	-	Gravel	Hard	Dom. Stk.	Sufficient for 30 head
35	NE	Dug	956	22	15	-	-	Hard	Dom. Stk.	" " 20 "

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 4, Range 7

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Dug	1,363	12	8	-	Drift	Hard	Dom. Stk.	- - -
2	SW	Dug	1,449	28	18	-	Gravel	Hard	Dom. Stk.	- - -
3	SW	Dug	1,464	23	8	-	-	Hard	Dom. Stk.	Sufficient for 20 head
4	NW	Dug	1,504	22	11	-	-	Hard	Dom. Stk.	- - -
5	SE	Dug	1,549	30	18	-	-	Hard	Dom. Stk.	Sufficient for 20 head
6	SW	Dug	1,608	30	27	-	-	Hard	Not	- - -
8	SE	Dug	1,527	30	29	-	Drift	Hard	Dom. Stk.	Also a dugout
9	NW	Dug	1,515	22	17	-	Drift	Hard	Dom. Stk.	Sufficient for 30 head
10	NE	Brd.	1,449	24	12	-	Drift	Hard	Dom. Stk.	- - -
12	NW	Dug	1,409	38	10	-	Drift	Hard	Dom. Stk.	Sufficient for 15 head
13	NW	Dug	1,430	20	16	-	Drift	Hard	Dom. Stk.	- - -
14	SE	Dug	1,430	68	28	-	-	Hard	Dom. Stk.	Also a well 20 ft. deep
15	SW	Dug	1,458	25	20	-	-	Hard	Dom. Stk.	Also a well 40 ft. deep
16	SW	Dug	1,516	40	39	8	R.M.	Hard	Dom. Stk.	Not sufficient
17	SE	Dug	1,535	19	11	-	-	Hard	Dom. Stk.	Sufficient for 20 head
20	NE	Dug	1,492	24	5	-	-	Hard	Dom. Stk.	- - -
21	SW	Dug	1,484	24	12	-	-	Hard	Dom. Stk.	Sufficient for 20 head
22	SE	Brd.	1,441	20	15	-	-	Hard	Dom. Stk.	" " 20 "
23	SE	Dug	1,419	30	27	3	R.M.	-	Dom. Stk.	- - -
24	NW	Brd.	1,176	50	48	-	Sand	Hard	Stk.	- - -
27	SE	Dug	1,401	20	13	-	-	Hard	Dom. Stk.	Also a dugout
28	NE	Dug	1,429	22	16	4	V.R.	Hard	Dom. Stk.	Sufficient for 25 head
29	NW	Dug	1,528	32	29	6	V.R.	Hard	Stk.	" " 40 "
30	SW	Dug	1,600	30	20	-	Gravel	Hard	Dom. Stk.	" " 20 "
34	NW	Dug	1,600	40	35	35	V.R.	Hard	Dom. Stk.	" " 20 "
33	SE	Dug	1,406	20	12	4	V.R.	Hard	Dom. Stk.	Also a bored well 28 ft. deep
34	SW	Dug	1,411	20	14	4	V.R.	Hard	Dom. Stk.	- - -
35	SW	Dug	1,314	20	16	-	-	Hard	Dom. Stk.	- - -
36	SW	Dug	1,168	30	24	-	Sand	Hard	Dom. Stk.	- - -

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 4, Range 8

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Dug	1,632	15	9	-	-	Hard	Dom.	Also a stock well 75 feet deep
3	SE	Dug	1,624	19	10	6	R.M.	Hard	Dom. Stk.	Sufficient for 20 head
4	NW	Dug	1,621	20	9	-	-	Hard	Dom.	Stock well 40 ft. deep
5	SE	Dug	1,611	20	6	-	-	Hard	Dom. Stk.	Sufficient for 40 head
7	SE	Brd.	1,584	57	10	-	-	Hard	Dom. Stk.	" " 10 "
8	SE	Dug	1,599	25	10	-	-	Hard	Dom.	Water at 18 ft.
9	SW	Brd.	1,597	45	30	-	-	Hard	Dom. Stk.	Also a well 55 ft. deep
10	NW	Brd.	1,591	45	15	-	Drift	Hard	Dom.	Also a well 48 ft. deep
11	NE	Drl.	1,621	90	18	85	R.M.	Soft	Dom. Stk.	Sufficient for 20 head
12	NE	Brd.	1,604	23	11	-	Drift	Hard	Stk.	- - -
13	NW	Brd.	1,604	13	10	-	Drift	Hard	Dom. Stk.	Not sufficient
14	SW	Brd.	1,629	40	15	-	Drift	Hard	Dom. Stk.	Sufficient for 20 head
15	SE	Brd.	1,630	26	10	6	R.M.	Hard	Dom.	Also a bored well 70 ft. deep
16	SE	Brd.	1,604	65	25	35	R.M.	Hard	Dom. Stk.	- - -
17	NW	Brd.	1,614	150	12	-	-	Hard	Dom. Stk.	Sufficient for 40 head
18	NE	Dug	1,609	25	6	10	R.M.	Hard	Dom.	Stock well 35 ft. deep
19	NE	Dug	1,640	90	28	12	R.M.	Hard	Stk.	House well 40 ft. deep
20	NW	Dug	1,627	20	12	12	R.M.	Hard	Dom.	- - -
22	NW	Brd.	1,665	80	10	20	R.M.	Hard	Stk.	Two other wells on farm
23	SE	Brd.	1,601	38	8	6	R.M.	Hard	Dom. Stk.	Dugout for stock
24	NW	Dug	1,606	53	7	-	-	Hard	Dom.	School well
25	SW	Dug	1,599	19	12	-	-	Hard	Dom. Stk.	- - -
26	SE	Dug	1,611	41	10	12	R.M.	Hard	Dom. Stk.	- - -
27	NW	Drl.	1,639	117	44	88	R.M.	Soft	Dom. Stk.	- - -
29	SE	Brd.	1,639	20	8	-	-	Hard	Dom.	Also a stock well 23 ft. deep
30	NE	Dug	1,637	22	10	4	R.M.	Soft	Dom. Stk.	Sufficient for 60 head
31	SE	Dug	1,636	18	12	10	R.M.	Hard	Dom. Stk.	- - -
32	SW	Brd.	1,635	60	25	30	R.M.	Hard	Dom. Stk.	Sufficient for 40 head
34	NE	Dug	1,615	39	13	12	R.M.	Hard	Dom.	Also a stock well 52 ft. deep
36	SE	Brd.	1,606	34	8	31	R.M.	Hard	Stk.	- - -

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 4, Range 9

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SW	Dug	1,631	30	20	5	R.M.	Hard	Dom.	- - -
2	SE	Brd.	1,625	42	20	-	R.M.	Hard	Dom. Stk.	Sufficient for 20 head
4	SE	Dug	1,576	48	-	-	R.M.	Hard	Dom. Stk.	Sufficient for 20 head
5	NE	Dug	1,559	45	15	12	R.M.	Hard	Dom. Stk.	Sufficient for 50 head
7	NE	Brd.	1,536	28	23	-	R.M.	Hard	Dom.	- - -
8	NW	Dug	1,546	26	20	20	R.M.	Hard	Dom. Stk.	Sufficient for 30 head
10	SW	Dug	1,552	12	6	4	R.M.	Hard	Dom. Stk.	" " 30 "
11	SE	Dug	1,621	25	15	-	R.M.	Hard	Stk.	Sufficient for 60 head
12	SW	Brd.	1,626	35	20	8	R.M.	Hard	Dom. Stk.	" " 25 "
13	NE	Dug	1,596	27	16	-	-	Hard	Dom. Stk.	- - -
14	SW	Dug	1,576	28	22	-	-	Hard	Stk.	Sufficient for 50 head
15	SE	Drl.	1,571	135	-	-	R.M.	Soft	Dom. Stk.	- - -
16	NW	Brd.	1,553	45	10	15	R.M.	Hard	Dom. Stk.	Sufficient for 40 head
17	SW	Brd.	1,540	48	28	10	R.M.	Hard	Dom. Stk.	Also a dug well 24 ft. deep
18	SW	Drl.	1,544	42	15	-	Drift	Hard	Dom. Stk.	- - -
19	SE	Dug	1,529	28	25	-	-	Hard	Dom. Stk.	Sufficient for 48 head
20	SW	Brd.	1,534	20	17	-	-	Hard	Dom. Stk.	" " 20 "
21	NW	Drl.	1,594	122	30	-	-	Soft	Dom. Stk.	Two other wells 60 and 80 ft. deep
22	SE	Brd.	1,594	50	25	3	R.M.	Hard	Dom. Stk.	Sufficient for 40 head
24	SE	Dug	1,613	30	12	6	R.M.	Hard	Dom. Stk.	" " 40 "
26	SE	Dug	1,613	29	19	-	-	Hard	Dom. Stk.	" " 30 "
27	NE	Dug	1,622	46	40	20	R.M.	Hard	Dom. Stk.	" " 15 "
29	SE	Brd.	1,583	80	20	-	R.M.	Hard	Dom. Stk.	Also a dug well 30 ft. deep
30	SE	Brd.	1,553	47	17	25	R.M.	Hard	Dom. Stk.	Sufficient for 25 head
31	NE	Dug	1,564	22	16	-	-	Hard	Stk.	- - -
32	NW	Dug	1,563	51	35	30	R.M.	Hard	Dom. Stk.	Also a well 52 ft. deep
33	NW	Dug	1,616	20	12	5	R.M.	Hard	Dom. Stk.	Sufficient for 25 head
34	NE	Dug	1,642	40	15	12	R.M.	Hard	Dom. Stk.	Also a bored well 105 ft. deep

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 5, Range 6

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
2	SE	Dug	957	30	24	-	-	Hard	Dom. Stk.	Sufficient supply
3	NE	Dug	954	11	7	-	Drift	Hard	Dom. Stk.	Sufficient for 15 head
4	NW	Dug	991	15	8	-	Gravel	Hard	Dom. Stk.	Abundant supply
6	NW	Dug	1,064	35	18	-	Gravel	Hard	Dom. Stk.	Sufficient for 80 head
7	NE	Dug	1,033	19	10	-	Sand	Hard	Dom. Stk.	" " 20 "
8	NE	Dug	996	22	19	-	Gravel	Hard	Dom. Stk.	" " 55 "
9	SW	Dug	992	14	9	-	Drift	Hard	Dom. Stk.	- - -
10	SE	Dug	957	115	-	-	-	Hard	Dom. Stk.	- - -
13	NE	Dug	929	54	13	-	-	Hard	Stk.	- - -
14	NE	Drl.	940	140	29	-	Sand	-	-	Water at 130 ft. in coarse sand
15	NW	Dug	957	12	6	-	-	Hard	Stk.	- - -
16	NW	Dug	981	26	17	-	-	Hard	Dom.	Also a well 40 ft. deep
17	SW	Dug	1,009	20	14	-	Sand	Hard	Dom. Stk.	Sufficient for 20 head
18	SW	Dug	1,020	12	6	-	Gravel	Hard	Dom. Stk.	" " 15 "
19	SW	Dug	996	25	10	-	Sand	Hard	Dom. Stk.	" " 35 "
20	SW	Dug	979	13	7	-	-	Hard	Dom. Stk.	" " 40 "
21	SW	Dug	983	21	14	-	Drift	Hard	Stk.	Temp. of water 42^{o} F.
23	NW	Drl.	939	160	40	-	-	Hard	Dom. Stk.	Sufficient for 65 head
24	SE	Drl.	929	112	30	-	-	Hard	Dom. Stk.	" " 50 "
25	SW	Dug	931	24	10	-	-	Hard	Dom. Stk.	- - -
28	SE	Dug	961	18	14	-	Drift	Hard	Stk.	Sufficient for 30 head
29	SE	Drl.	962	117	15	-	-	Hard	Dom. Stk.	Also a well dug 22 ft. deep
31	SE	Drl.	978	200	50	-	Gravel	Soft	Dom.	Not sufficient
32	SE	Dug	967	21	11	-	Drift	Hard	Dom.	- - -
33	SW	Drl.	967	60	30	-	Drift	Hard	Dom. Stk.	Sufficient for 15 head
34	NW	Dug	949	18	1	-	Sand	Hard	Dom. Stk.	" " 15 "
35	NE	Drl.	922	120	33	-	-	Hard	Dom. Stk.	" " 60 "
36	NW	Dug	925	14	11	-	-	Hard	Dom.	Also a drilled well 220 ft. deep

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 5, Range 7

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
2	SE	Dug	1,090	15	9	-	Drift	Hard	Dom. Stk.	- - -
3	NE	Dug	1,198	36	26	-	-	Hard	Stk.	Sufficient for 20 head
4	SE	Dug	1,414	30	25	10	V.R.	Hard	Dom. Stk.	Not sufficient
5	SW	Dug	1,459	26	20	-	Drift	Hard	Dom.	Also a stock well
7	SE	Dug	1,456	38	16	14	V.R.	Hard	Dom. Stk.	Water at 35 ft. in shale
8	NE	Dug	1,406	25	15	12	V.R.	Hard	Dom. Stk.	Sufficient for 30 head
9	SE	Dug	1,336	20	16	-	Drift	-	Stk.	Not sufficient
10	SW	Dug	1,308	29	12	-	-	Hard	Dom. Stk.	- - -
11	SW	Dug	1,147	12	9	-	Drift	Hard	Dom. Stk.	Sufficient for 40 head
13	SE	Dug	1,059	24	19	-	Gravel	Hard	Dom. Stk.	- - -
14	SW	Dug	1,109	20	10	-	-	Hard	Dom. Stk.	Sufficient for 20 head
15	SW	Dug	1,212	22	19	-	-	Hard	Dom. Stk.	" " 30 "
17	NE	Dug	1,405	25	8	-	-	Hard	Dom.	- - -
18	SE	Dug	1,420	50	12	10	V.R.	Hard	Dom. Stk.	- - -
20	SW	Dug	1,412	16	8	-	-	Hard	Stk.	Also a house well dug 14 ft. deep
22	NE	Dug	1,103	20	15	-	Drift	Hard	Dom. Stk.	Sufficient for 35 head
23	SW	Dug	1,111	54	44	-	-	Hard	Dom. Stk.	" " 20 "
25	NW	Dug	998	17	13	-	-	Hard	Stk.	- - -
26	SW	Dug	1,054	26	23	-	-	Hard	Dom. Stk.	Temp. of water 23°F.
28	NE	Dug	1,126	30	25	-	Sand	Hard	Dom. Stk.	- - -
30	NW	Dug	1,427	60	35	-	-	Soft	Dom. Stk.	Sufficient for 25 head
31	SW	Dug	1,390	6	4	-	-	Soft	Dom. Stk.	- - -
32	NW	Dug	1,275	26	16	24	V.R.	Hard	Dom. Stk.	Sufficient for 40 head
34	SW	Dug	1,110	29	22	-	Sand	Hard	Dom. Stk.	Sufficient for 75 head
35	SW	Dug	1,049	35	20	-	Drift	Hard	Dom. Stk.	" " 40 "
35	NW	Dug	959	20	10	-	-	Hard	Dom. Stk.	" " 30 "
36	NE	Dug	990	19	8	-	-	Hard	Stk.	- - -

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 5, Range 8

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
3	NE	Brd.	1,599	56	10	18	V.R.	Hard	Stk.	Sufficient for 50 head
5	SW	Dug	1,644	17	10	-	-	Hard	Dom.	- - -
6	SE	Brd.	1,653	35	20	34	R.M.	Soft	Dom. Stk.	Sufficient for 25 head
7	SW	Dug	1,623	18	7	10	R.M.	Hard	Dom.	Also a stock well 60 ft. deep
8	NW	Dug	1,644	16	14	-	-	Hard	Dom.	Also a drilled well for stock
9	NE	Brd.	1,617	53	23	-	-	Hard	Dom. Stk.	Sufficient for 25 head
13	NE	Dug	1,488	20	17	4	R.M.	Hard	Dom.	Also a stock well bored 45 ft. deep
14	NE	Dug	1,521	28	18	24	R.M.	Hard	Dom.	Also a stock well 19 ft. deep
16	NE	Dug	1,587	28	19	-	-	Hard	Dom. Stk.	Sufficient for 25 head
17	SE	Dug	1,625	30	7	-	-	Hard	Dom. Stk.	- - -
18	SE	Brd.	1,620	63	20	20	R.M.	Hard	Dom.	Also a stock well
18	SW	Dug	1,626	40	5	8	R.M.	Hard	Dom. Stk.	Also a well 32 ft. deep
19	NE	Dug	1,602	45	15	10	R.M.	Hard	Dom. Stk.	Sufficient for 20 head
21	NW	Dug	1,506	35	29	10	R.M.	Hard	Dom. Stk.	Also a well 26 ft. deep
22	SE	Dug	1,579	25	15	-	-	Hard	Dom.	Also a stock well 30 ft. deep
23	NE	Dug	1,464	18	7	-	-	Hard	Not	- - -
24	SW	Dug	1,479	18	11	-	-	Hard	Dom. Stk.	Sufficient for 15 head
26	NE	Dug	1,454	25	10	-	Drift	Hard	Dom.	Also a well 45 ft. deep
27	NE	Brd.	1,500	34	18	15	R.M.	Hard	Dom. Stk.	Sufficient for 30 head
29	SE	Dug	1,549	13	-	-	-	Hard	Dom. Stk.	- - -
30	NE	Dug	1,579	32	20	-	-	Hard	Dom. Stk.	Sufficient for 26 head
31	SE	Dug	1,575	16	12	6	R.M.	Hard	Dom. Stk.	" " 25 "
32	SW	Dug	1,587	21	13	4	R.M.	Hard	Dom. Stk.	" " 15 "
33	NW	Brd.	1,524	20	10	15	R.M.	Hard	Dom. Stk.	" " 30 "
34	SW	Dug	1,505	12	7	-	Drift	Hard	Dom. Stk.	" " 30 "
35	NW	Dug	1,445	32	18	-	-	Hard	Dom. Stk.	- - -
36	SE	Brd.	1,405	27	14	4	R.M.	Hard	Dom. Stk.	Water at 14 ft. in shale

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 5, Range 9

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NW	Dug	1,620	30	24	-	-	Hard	Dom. Stk.	Also a well 35 ft. deep
2	NE	Dug	1,651	32	31	-	-	Hard	Dom. Stk.	- - -
3	NW	Dug	1,618	30	15	15	R.M.	Hard	Dom. Stk.	- - -
5	SE	Brd.	1,592	80	23	-	R.M.	Hard	Stk.	Sufficient for 18 head
6	NE	Dug	1,569	27	10	-	-	Hard	Dom. Stk.	" " 15 "
7	NE	Brd.	1,584	50	30	-	-	Hard	Dom. Stk.	" " 20 "
8	SW	Dug	1,570	22	10	15	R.M.	Hard	Dom. Stk.	- - -
10	SE	Brd.	1,645	100	30	10	R.M.	Hard	Dom. Stk.	Two other wells 50 and 15 ft. deep
11	NW	Dug	1,654	26	21	10	R.M.	Hard	Dom.	Also a stock well 50 ft. deep
12	NW	Brd.	1,608	60	30	45	R.M.	Hard	Stk.	Also a house well 13 ft. "
13	NE	Dug	1,631	22	15	-	-	Soft	Dom. Stk.	- - -
14	NE	Dug	1,604	30	12	-	-	Hard	Dom. Stk.	Also a well 25 ft. deep
16	SE	Dug	1,646	32	17	6	R.M.	Hard	Stk.	Also a house well 22 ft. deep
17	NE	Brd.	1,546	68	28	25	R.M.	Hard	Dom. Stk.	Sufficient for 20 head
18	SW	Dug	1,537	22	16	-	-	Hard	Stk.	" " 30 "
20	SE	Dug	1,591	45	30	10	R.M.	Hard	Dom. Stk.	Also a well 40 ft. deep
21	SE	Dug	1,649	35	33	8	R.M.	Hard	Dom. Stk.	Also a well 16 ft. deep
23	NE	Dug	1,633	17	15	6	R.M.	Hard	-	Also a well 19 ft. deep
24	NW	Dug	1,612	50	30	8	R.M.	Hard	Dom. Stk.	Sufficient for 18 head
25	SE	Dug	1,646	28	24	10	R.M.	Hard	Dom.	Stock well 25 ft. deep
26	NW	Dug	1,604	26	11	16	R.M.	Hard	Dom. Stk.	- - -
27	SE	Dug	1,604	41	17	-	R.M.	Hard	Dom. Stk.	Sufficient for 25 head
28	SE	Dug	1,625	40	12	6	R.M.	Hard	Dom. Stk.	" " 25 "
29	SW	Brd.	1,564	18	10	-	-	Hard	Dom.	- - -
30	SW	Dug	1,551	41	28	-	-	Hard	Dom. Stk.	- - -
31	SW	Dug	1,564	29	28	12	R.M.	Hard	Dom. Stk.	- - -
32	NW	Dug	1,569	26	21	-	-	Hard	Dom. Stk.	- - -
33	SE	Dug	1,576	38	30	-	-	Hard	Dom. Stk.	Sufficient for 22 head
34	NW	Dug	1,580	21	18	18	R.M.	Hard	Dom.	Also a stock well 22 ft. deep
36	SE	Dug	1,602	23	15	-	-	Hard	Dom.	- - -

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 6, Range 6

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Drl.	919	190	15	-	-	Hard	Not	Also a bored well 80 ft. deep
2	SE	Drl.	930	110	20	-	-	Hard	Stk.	Also a house well 10 ft. deep
3	SE	Dug	954	18	8	-	-	Hard	Dom.	Also a drilled well over 100 ft. deep
5	SW	Dug	977	16	11	-	Sand	Hard	Dom. Stk.	- - -
6	NE	Dug	978	16	6	-	Sand	Hard	Dom. Stk.	- - -
7	NE	Dug	986	22	12	-	Drift	Hard	Dom. Stk.	Sufficient for 40 head
8	SW	Dug	977	18	15	-	-	Hard	Dom. Stk.	" " 16 "
9	NW	Dug	963	13	10	-	Sand	Hard	Dom. Stk.	" " 25 "
11	NW	Dug	945	16	10	-	-	Hard	Dom. Stk.	- - -
12	NW	Drl.	927	225	27	-	Gravel	Hard	Not	Water in gravel at 225 ft.
13	NE	Drl.	920	105	14	-	-	Hard	Dom. Stk.	Sufficient for 30 head
14	SE	Dug	939	18	7	-	-	Hard	Dom. Stk.	Temp. of water 42° F.
15	SE	Drl.	959	160	12	-	Gravel	Hard	Stk.	Water in gravel at 150 ft.
17	SE	Dug	973	14	6	-	Sand	Hard	Dom. Stk.	Sufficient for 40 head
19	SW	Dug	990	18	8	-	Sand	Hard	Dom. Stk.	" " 80 "
20	SW	Dug	980	24	8	-	Sand	Hard	Dom. Stk.	" " 40 "
21	SW	Dug	965	12	8	-	Drift	Hard	Dom. Stk.	- - -
23	SE	Drl.	938	272	40	-	Sand	Hard	Stk.	Sufficient for 55 head
24	NW	Brd.	921	77	26	-	-	-	-	- - -
26	SE	Dug	913	24	20	-	Drift	Hard	Dom.	- - -
27	SE	Dug	935	12	9	-	Drift	Hard	Dom. Stk.	Sufficient for 35 head
29	NW	Dug	954	12	8	-	Drift	Hard	Dom. Stk.	- - -
30	NW	Dug	986	14	9	-	Sand	Hard	Dom. Stk.	Sufficient for 15 head
31	NW	Dug	984	9	6	-	Sand	Hard	Dom. Stk.	" " 9 "
33	NW	Dug	960	14	9	-	Sand	Hard	Dom. Stk.	" " 40 "
34	SW	Dug	944	13	9	-	Sand	Hard	Dom.	- - -
35	SE	Drl.	935	200	29	-	-	Hard	Stk.	Sufficient for 50 head
36	SE	Dug	934	22	6	-	Drift	Hard	Stk.	" " 35 "

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 6, Range 7

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Dug	988	21	10	-	-	Hard	Dom. Stk.	- - -
2	NW	Dug	996	13	8	-	-	Hard	Dom. Stk.	- - -
3	SW	Dug	1,036	14	11	-	Drift	Hard	Dom.	School well
5	NW	Brd.	1,263	40	24	-	Sand	Hard	Dom. Stk.	- - -
6	SE	Brd.	1,279	38	33	-	Sand	Hard	Dom. Stk.	- - -
10	SE	Dug	1,007	10	7	-	-	Hard	Dom. Stk.	- - -
11	NW	Dug	1,000	20	15	-	-	Hard	Stk.	- - -
12	SE	Dug	988	18	10	-	Sand	Hard	Dom. Stk.	- - -
13	NE	Dug	988	14	10	-	Sand	Hard	Dom.	- - -
14	SE	Dug	998	14	10	-	Sand	Hard	Dom. Stk.	Sufficient for 75 head
15	NE	Dug	1,007	18	12	-	Drift	Hard	Dom. Stk.	" " 25 "
16	NW	Dug	1,036	15	12	-	Drift	Hard	Dom. Stk.	" " 20 "
17	NE	Dug	1,048	16	8	-	Sand	Hard	Dom. Stk.	" " 60 "
18	NW	Dug	1,098	18	16	-	Gravel	Hard	Dom. Stk.	- - -
20	NE	Dug	1,014	14	10	-	Drift	Hard	Dom. Stk.	Sufficient for 50 head
21	NE	Dug	1,009	16	13	-	Drift	Hard	Dom. Stk.	- - -
22	SW	Dug	1,008	16	12	-	Sand	Hard	Dom. Stk.	- - -
23	NW	Dug	1,002	23	12	-	Sand	Hard	Dom. Stk.	" " 80 "
24	NW	Dug	992	25	10	-	Sand	Hard	Dom. Stk.	" " 40 "
25	SE	Dug	989	11	10	-	-	Hard	Stk.	- - -
26	NE	Dug	993	9	5	-	Drift	Hard	Dom. Stk.	Water is a yellow colour
27	NW	Dug	1,002	14	12	-	Sand	Hard	Dom. Stk.	- - -
28	NE	Dug	1,009	12	10	-	Drift	Hard	Dom. Stk.	- - -
32	SW	Dug	1,031	14	12	-	Drift	Hard	Dom. Stk.	Not sufficient
33	SW	Dug	1,011	14	10	-	Sand	Hard	Dom. Stk.	Sufficient for 30 head
34	SE	Dug	973	17	14	-	-	Hard	Dom. Stk.	" " 20 "
35	NE	Dug	991	8	7	-	Sand	Hard	Dom. Stk.	- - -
36	SE	Dug	986	11	9	-	Sand	Hard	Dom. Stk.	- - -

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 6, Range 8

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Dug	1,329	15	10	14	V.R.	Hard	Dom. Stk.	Sufficient for 30 head
3	NE	Dug	1,423	31	23	-	-	Hard	Dom. Stk.	" " 15 "
4	NE	Dug	1,480	30	10	-	-	hard	Dom.	- - -
5	SE	Dug	1,529	28	17	20	V.R.	Hard	Dom. Stk.	" " 23 "
6	NE	Dug	1,545	21	15	10	V.R.	Hard	Dom. Stk.	" " 15 "
7	SW	Dug	1,556	20	15	-	-	Hard	Dom. Stk.	" " 15 "
8	SE	Dug	1,533	31	14	-	-	Hard	Dom. Stk.	" " 30 "
9	SE	Dug	1,464	18	14	-	Drift	Hard	Dom.	Well at St. Lupicin Store
10	SW	Dug	1,460	20	18	-	Drift	Hard	Dom. Stk.	- - -
11	SE	Dug	1,345	27	20	-	-	Hard	Dom.	- - -
12	NE	Dug	1,282	35	25	-	Sand	Hard	Dom. Stk.	- - -
13	SW	Dug	1,130	15	10	-	Gravel	Hard	Dom.	- - -
14	NE	Dug	1,272	14	6	-	Drift	Hard	Dom. Stk.	Not sufficient for 10 head
15	NE	Dug	1,330	9	2	-	Drift	Hard	Dom. Stk.	Sufficient for 50 head
17	SW	Dug	1,500	32	19	-	-	Hard	Dom. Stk.	- - -
18	NW	Dug	1,519	39	19	-	-	Hard	Dom. Stk.	- - -
19	NE	Dug	1,512	28	23	-	Drift	Hard	Dom. Stk.	Sufficient for 15 head
21	SW	Dug	1,513	35	25	-	-	Hard	Dom. Stk.	" " 10 "
22	NW	Dug	1,398	28	20	-	Sand	Hard	Dom. Stk.	- - -
26	NE	Drl.	1,252	108	33	-	Gravel	Hard	Dom. Stk.	Sufficient for 33 head
27	NW	Dug	1,350	10	5	-	Gravel	Hard	Dom. Stk.	" " 22 "
28	SE	Dug	1,382	47	40	-	-	Hard	Dom. Stk.	" " 30 "
30	SE	Dug	1,538	38	34	-	Drift	Hard	Dom. Stk.	" " 15 "
31	NW	Dug	1,551	18	11	-	Sand	Hard	Dom. Stk.	" " 35 "
32	NW	Dug	1,503	40	35	-	-	Hard	Dom. Stk.	" " 25 "
33	SE	Dug	1,345	19	13	-	-	Hard	Dom. Stk.	- - -
34	SW	Dug	1,539	18	8	-	Drift	Hard	Dom. Stk.	Sufficient for 20 head
36	SE	Dug	1,121	8	4	-	Sand	Hard	Dom. Stk.	" " 20 "

REPRESENTATIVE WELL RECORDS, MANITOU AREA, MANITOBA

Township 6, Range 9

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Dug	1,574	22	18	11	R.M.	Hard	Dom.	Also a stock well 36 ft. deep
3	SE	Dug	1,574	28	8	-	R.M.	Hard	Dom. Stk.	Sufficient for 15 head
4	SW	Dug	1,574	30	20	-	-	Hard	Dom. Stk.	- - -
5	SE	Dug	1,562	30	24	-	-	Hard	Dom. Stk.	Sufficient for 30 head
6	SE	Dug	1,598	36	18	-	-	Hard	Dom. Stk.	" " 20 "
7	SW	Dug	1,543	50	-	-	-	Hard	Dom. Stk.	" " 30 "
8	NE	Dug	1,557	43	19	-	-	Hard	Dom. Stk.	" " 20 "
12	NW	Dug	1,544	20	15	5	R.M.	Hard	Dom.	Also a stock well 30 ft. deep
13	SE	Dug	1,544	25	17	12	R.M.	Soft	Dom. Stk.	- - -
13	SW	Dug	1,537	35	10	9	R.M.	Hard	Dom.	Also a bored well 32 ft. deep
14	SE	Dug	1,547	34	24	9	R.M.	Hard	Dom. Stk.	- - -
15	NE	Dug	1,570	22	12	-	-	Hard	Dom. Stk.	Sufficient for 15 head
16	SE	Dug	1,570	40	25	-	Gravel	Hard	Dom. Stk.	" " 15 "
17	NW	Brd.	1,552	22	18	-	-	Hard	Dom. Stk.	" " 30 "
18	SE	Dug	1,546	25	11	-	Drift	Hard	Dom. Stk.	Two other wells 26 and 12 ft. deep
19	NE	Dug	1,548	21	16	-	-	Hard	Dom. Stk.	- - -
20	SW	Dug	1,554	33	29	12	R.M.	Soft	Dom. Stk.	Sufficient for 30 head
21	NW	Dug	1,568	31	19	20	R.M.	Hard	Dom. Stk.	- - -
22	SW	Dug	1,592	34	29	-	-	Hard	Dom. Stk.	Sufficient for 25 head
23	SW	Dug	1,523	44	14	14	R.M.	Hard	Stk.	- - -
24	SE	Dug	1,510	35	25	-	Sand	Hard	Dom.	- - -
25	NW	Dug	1,527	30	15	6	R.M.	Hard	Dom. Stk.	Sufficient for 30 head
27	SE	Dug	1,560	25	18	-	R.M.	Hard	Dom. Stk.	" " 25 "
28	NW	Dug	1,546	27	14	-	-	Hard	Dom. Stk.	- - -
29	SE	Dug	1,573	33	24	26	R.M.	Hard	Dom. Stk.	- - -
30	SW	Dug	1,565	30	20	10	R.M.	Hard	Dom. Stk.	Sufficient for 30 head
31	SE	Dug	1,535	16	14	12	R.M.	Hard	Dom.	- - -
32	SW	Dug	1,556	35	33	20	R.M.	Hard	Dom. Stk.	Also a well bored 90 ft. deep
34	NW	Dug	1,568	22	15	-	-	Hard	Dom.	Also a stock well 36 ft. deep
36	SE	Dug	1,570	48	37	-	-	Hard	Dom. Stk.	Sufficient for 15 head

CANADA

DEPARTMENT OF MINES

AND

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GROUND-WATER RESOURCES OF TOWNSHIPS 1 to 6, RANGES 10 to ,13 WEST OF PRINCIPAL MERIDIAN, MANITOBA

(Pilot Mound Area)

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PART I

INTRODUCTION

The present report is an attempt to assemble the data on ground-water resources in a form that will be useful to well drillers, farmers, municipal authorities, and others interested in obtaining adequate water supplies.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports that, in Manitoba, cover a square block of sixteen townships lying between the correction lines and beginning at the Saskatchewan boundary. The reports on the most southerly strip of the province include in addition the two townships lying north of the International Boundary. The secretary-treasurer of each municipality will be supplied with the information covering that municipality, and copies of the reports will also be available for study at offices of the Provincial and Federal Departments. Further assistance in interpreting the reports may be obtained by applying to the Chief Geologist, Geological Survey of Canada, Ottawa.

How to Use the Report

Anyone desiring information concerning ground-water in any particular locality will find the available data listed in the well records, and other pertinent information on the maps of the area. For those unfamiliar with these reports it is, perhaps, advisable that that part dealing with the area as a whole be read first, so as to be in a better position to understand the more particular descriptions of each township that follow. Also, the map accompanying the report should prove a useful source of reference when reading the text.

The map consists of two figures. Figure I shows bedrock and surface geology. The water-bearing properties of the bedrock change from formation to formation, and are referred to in subsequent pages. The type of glacial deposit at the surface may be determined from the map, and its possibilities as an aquifer are also discussed in this report.

Figure 2 shows the location and types of wells in the area, the land relief (topography), and the drainage pattern. Not every well is plotted on the map, but most of those giving pertinent information are shown, and probably include 90 per cent of the wells in the area. Where ground water is not readily available, or carries too much dissolved salts to be used, dugouts often form the only means of supply. The topography is shown by contours, or lines of equal elevation, spaced at vertical intervals of 50 feet.

The well records are compiled from data obtained by interviewing farmers, and in many cases their accuracy depends upon the farmer's memory. Wherever possible data were checked by plumb-line measurement to the nearest foot. The wells are tabulated by townships and sections, and the total depth of the well, depths to the water level at high and low stages, and, where possible, the depth at which the water-bearing horizon occurs, are all listed. The general character of the water is stated, and the use to which it can be put. Wells from which samples were taken for analysis are indicated on the well-record sheets. An idea of how much water a well can be expected to yield is suggested by the number of stock (cattle and horses only) that can be watered at it. One head is assumed to consume between 8 and 10 gallons of water a day. Unless followed by the word "only"

the figure for the number of stock watered is not necessarily the maximum yield of the well, but simply the greatest amount that the present user has required. The word "only" indicates that the figure given is the maximum yield of the well. To obtain the position of an aquifer at any given point, the elevation of the point should be determined from the contours on Figure 2 of the map. Elevations of adjacent wells may be found in the well records and the depth to the aquifer can usually be determined from them. By comparing elevations the depth of the aquifer below the unknown point may be estimated. This method is particularly applicable to bedrock wells, but may not be successful where information is too limited, or where the glacial drift is thick and of an irregular character. In such instances a person searching for water should refer to the text for information on the nature of the deposits in that area.

GLOSSARY OF TERMS USED

Alkaline. The term 'alkaline' or 'alkali' water has been applied rather loosely to waters having a peculiar and disagreeable taste, and commonly a laxative effect. The waters so described in the Prairie Provinces are those heavily charged with sulphates of magnesium and sodium (respectively Epsom salts and Glauber's salts) and are more correctly termed sulphate waters. Truly 'alkaline' waters owe that property to the presence of calcium carbonate and calcium bicarbonate. In this report an attempt to adhere to local terminology is made by referring to sulphate waters as 'alkali' in the well records, and the term 'alkaline' is avoided.

Alluvium. Deposits of clay, silt, sand, gravel, and other material in lake beds and in flood plains of modern streams. The term also includes the material in river terraces, which once formed part of the flood plain but are now above it.

Aquifer. A porous bed, lens, pocket, or deposit of material that transmits water in sufficient quantity to satisfy pumping wells and springs.

Bedrock. Bedrock, as here used, refers to partly or wholly consolidated deposits of gravel, sand, silt, clay, and marl that are older than the glacial drift.

Bentonite and bentonitic clays have the property of swelling when water is added to them. They occur as white beds as much as 2 feet thick, but usually much thinner, and are probably formed by the weathering of volcanic ash.

Buried pre-Glacial Stream Channel. A channel eroded into the surface of the bedrock by a stream before the advance of the continental ice-sheet, and subsequently either partly or wholly filled in by sands, gravels, and boulder clay deposited by the ice-sheet or later agencies.

Coal Seam. The same as a coal bed. It is a deposit of carbonaceous material formed from the remains of plants by partial decomposition and burial.

Contour. A line on a map joining points that have the same elevation above sea-level.

Continental Ice-sheet. The great ice-sheet that covered most of the surface of Canada many thousands of years ago.

Escarpment. A cliff or relatively steep slope separating level or gently slopping areas.

Flood Plain. A flat part of a river valley ordinarily above water but submerged when the river is in flood. It is an area where silt and clay are being deposited.

Glacial Drift. A general term that includes all the loose, unconsolidated materials that were deposited by the ice-sheet, or by the waters associated with it. Clay containing boulders usually forms a large part of the glacial drift in an area, and is called glacial till or boulder clay, and is not to be confused with the more general term glacial drift, which occurs in the following several forms:

(1) Terminal Moraine or Moraine. A ridge or series of ridges formed by glacial drift that was laid down at the margin of a moving ice-sheet. The surface is characterized by irregular hills and undrained basins.

(2) Kame Moraine. Assorted deposits of sand and gravel laid down at or close to the ice margin. The topography is similar to that of a terminal moraine.

(3) Ground Moraine. Boulder clay (till) laid down at the base of an ice-sheet. The topography may vary from flat to gently rolling.

(4) Glacial Outwash. Sand and gravel plains or deltas formed by streams that issued from the continental ice-sheet.

(5) Glacial-lake Deposits. Sand, silt, and clay deposited in glacial lakes during the retreat of the ice-sheet.

Shoreline. A discontinuous escarpment, with intervening gravel beaches and bars, which indicates the former margin of a glacial lake.

Ground Water. The water in the zone of saturation below the water-table.

Hydrostatic Pressure. The pressure that causes water in a well to rise above the point at which it was first encountered in the well, namely, at the level of the aquifer.

Impervious or impermeable. Beds such as fine clays or shale are considered to be impermeable when they do not permit the perceptible passage or movement of ground water.

Pervious or Permeable. Beds are pervious or permeable when they permit the perceptible passage or movement of ground water, as in the case of sands and gravels.

Pre-Glacial Land Surface. The surface of the land as it existed before the ice-sheet covered it with drift.

Recent Deposits. Deposits that have been laid down by the agencies of water and wind since the disappearance of the continental ice-sheet; for example, alluvium in stream valleys.

Sand Point or Driven Well. A sand point is a piece of perforated and screened pipe 2 or 3 feet long, which ends in a sharp point. It is fastened to lengths of ordinary pipe and forced down into surface deposits of a sandy or gravelly nature. The depth of such a well rarely exceeds 30 feet.

Unconsolidated Deposits. The mantle or covering of alluvium, pre-glacial soils, and glacial drift consisting of loose, uncemented material that overlies the bedrock.

Variegated. Beds so described show different colours in alternating beds or lenses.

Water-table. The upper limit of the part of the ground saturated with water. This may be near the surface or many feet below it. A water-table is said to be perched when a zone of saturated material is separated from the main water-table below by a zone or zones of unsaturated material.

Water-worked Till. Glacial till or boulder clay that has been subjected to water action, usually near the margins of glacial lakes, so that the fine clay has been washed out and a deposit that may be composed mainly of sand and gravel is left behind.

Wells. The term refers to any hole sunk in the ground by any means for the purpose of obtaining water. If no water is obtained they are referred to as dry holes. Wells yielding water are divided into four classes:

(1) Flowing Artesian Wells. Wells in which the water is under sufficient hydrostatic pressure to flow above the surface of the ground at the well.

(2) Non-flowing Artesian (Sub-artesian) Wells. Wells in which the water is under sufficient hydrostatic pressure to raise it above the level of the aquifer, but not above the level of the ground at the well.

(3) Non-artesian Wells. Wells in which the water does not rise above the water-table or the aquifer.

(4) Intermittent Non-artesian Wells. Wells that are generally dry for a part of each year.

GENERAL DISCUSSION OF GROUND WATER

Almost all the water recovered from beneath the earth's surface for both domestic and industrial uses is meteoric water, that is, water derived from the atmosphere. Most of this water reaches the surface as rain or snow. Part of it is carried off by streams as run-off; part evaporates either directly from the surface and from the upper mantle of soil, or indirectly through transpiration of plants; and the remainder sinks into the ground to be added to the ground-water supplies.

The proportion of the total precipitation that sinks into the ground will depend largely upon the type of soil or surface rock, and on the topography; more water will sink into sand and gravel, for example, than into clay; if, on the other hand, the region is hilly and dissected by numerous streams, more water will be immediately drained from the surface than in a relatively flat area. Light, continued precipitation will furnish more water to the underground supply than brief torrential floods, during which the run-off may be nearly equal to the precipitation. Moisture failing on frozen ground will not usually find its way below the surface, and, therefore, will not materially replenish the ground-water supplies. Light rains falling during the growing season may be wholly absorbed by plants. The quantity of moisture lost through direct evaporation depends largely upon temperature, wind, and humidity. Locally these deposits may become very extensive. The water-bearing properties of alluvial deposits are variable, but, in general, such deposits form favourable aquifers. They are porous, and readily yield a part of their contained water, although in places their porosity may be greatly reduced by the presence of fine silt and clay. This type of deposit may be expected to yield moderate domestic supplies through shallow wells, and larger supplies if the deposits are extensive.

In some areas of relatively steep slopes, valleys have been partly filled with sand and gravel, which, in turn, have been covered with impervious clay and silt. These circumstances commonly give rise to artesian conditions in the lower part of the valley.

DISCUSSION OF WATER ANALYSES

Both the kind and quantity of mineral matter dissolved in a natural water depend upon the texture and chemical composition of the rocks with which the water has been in contact. Pollution is caused by contact with organic matter or its decomposition products. Analyses of well waters for mineral content are made by the Department of Health and Public Welfare, Winnipeg, and by the Bureau of Mines, Department of Mines and Resources, Ottawa.

As the ground-water survey of Manitoba progresses an effort is made to secure samples representative of each major aquifer encountered; the purpose of this is to compare the chemical characteristics of waters from the various geological horizons and, thereby, assist in making correlations of the strata in which the waters occur. The mineral content of natural waters is also of interest to the consumers, though the effects of the constituents are usually already apparent. The quantities of the various constituents for which tests are made are given as 'parts per million', which refers to the proportion by weight of each constituent in 1,000,000 parts of water. A salt when dissolved in water separates into two chemical units called 'radicals', and these are expressed as such in the chemical analyses. In one group are included the metallic elements of calcium (Ca), magnesium (Mg), sodium (Na), and iron (Fe), and in the other group are the sulphate (SO_4), chloride (Cl), bicarbonate (HCO_3), carbonate (CO_3), and nitrate (NO_3) radicals. The radicals listed in the analyses tabulated in the second part of this report can be combined to give the actual quantity of the particular salts present in the water, but this is not done here as the radicals alone give enough information to identify the water types. In fact, the sulphate, chloride, and carbonate radicals, plus the hardness, serve to identify a water, and crude field tests on the basis of these constituents were used in some areas to outline more completely zones of the various water types.

The following mineral constituents include all that are commonly found in natural waters in quantities sufficient to have any practical effect on the value of waters for ordinary uses:

Silica (SiO_2) is dissolved in small quantities from almost all rocks. It is not objectionable except in so far as it contributes to the formation of boiler scale.

Iron (Fe) in combination is dissolved from many rocks as well as from iron sulphide deposits with which the water comes in contact. It may also be dissolved from well casings, water pipes, and other fixtures in quantities large enough to be objectionable, but separates as the hydrated oxide upon exposure of the water to the atmosphere. Excessive iron in water causes straining on porcelain or enamelled ware, and renders the water unsuitable for laundry purposes. Water is usually considered not potable if the iron content is more than 0.5 part per million.

Calcium (Ca) in the water comes from mineral particles present in the surface deposits, the chief sources being limestone, gypsum, and dolomite. Fossil shells provide a source of calcium, as does also the decomposition of igneous rocks. The common compounds of calcium are calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$), neither of which have injurious effects on the consumer, but both of which cause hardness.

Magnesium (Mg) is a common constituent of many igneous rocks and, therefore, very prevalent in ground water. Dolomite, a carbonate of calcium and magnesium, is also a source of the element. The sulphate of ...

magnesia ($MgSO_4$) combines with water to form 'Epsom salts,' and renders the water unwholesome if present in large amounts.

Sodium(Na) is derived from a number of the important rock-forming minerals, so that sodium sulphate and carbonate are very common in ground waters. Sodium sulphate (Na_2SO_4) combines with water to form 'Glauber's salt' and excessive amounts make the water unsuitable for drinking purposes. Sodium carbonate (Na_2CO_3) or 'black alkali' waters are mostly soft, the degree of softness depending upon the ratio of sodium carbonate to the calcium and magnesium salts. Waters containing sodium carbonate in excess of 200 parts per million are unsuitable for irrigation purposes[1]. Sodium sulphate is less harmful.

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[1]"The extreme limit of salts for irrigation is taken to be 70 parts per 100,000, but plants will not tolerate more than 10 to 20 parts per 100,000 of black alkali (alkaline carbonates and bicarbonates)". Frank Dixey, in 'A Practical Handbook of Water Supply', Thos. Murby & Co., 1931, p. 254.

Sulphates (SO_4) referred to in this report are those of calcium, magnesium, and sodium, and have been mentioned above in referring to these radicals. They are also formed by oxidation of iron sulphides, and, hence, it is not uncommon to find iron in sulphate waters. Sulphates cause permanent hardness in water, and injurious boiler scale. Sodium and magnesium sulphates are laxative when present in quantities of more than 900 parts per million. The writers found that acclimatized people could drink water containing as much as 2,000 parts per million of all three of the principal sulphates, but that when all were present in quantities over 1,500 parts per million the water was commonly laxative to those not accustomed to it.

Chloride (Cl) is a constituent of all natural waters and is dissolved in small quantities from rocks. Waters from wells that penetrate brines or salt deposits contain large quantities of chloride, usually as sodium chloride (common salt) and less commonly as calcium chloride and magnesium chloride. Sodium chloride is a characteristic constituent of sewage, and any locally abnormal quantity suggests pollution from this source. However, such abnormal quantities should not, in themselves, be taken as positive proof of pollution in view of the many sources from which chloride may be derived. Chlorides impart a salty taste to water if present much in excess of 500 parts per million. In southwestern Manitoba waters with as much as 3,000 parts per million of chloride are used domestically, though more than 1,500 parts per million is generally considered undesirable. The following figures apply to chlorides: stock will require less salt if the water bears 2,000 parts per million; more than 5,000 parts per million is unfit for human consumption; more than 8,000 parts per million is unfit for horses; more than 9,500 parts per million is too much for cattle; and more than 15,500 parts per million is excessive for sheep. Magnesium chloride, less common than sodium chloride, is very corrosive to metal plumbing.

Nitrates(NO_3) found in ground water are decomposition products of organic materials; they are not harmful in themselves, but they do point to probable pollution. It is recommended that a bacterial test be made on water showing an appreciable nitrate content, if it is to be used for domestic purposes.

Carbonates (CO_3) in water are indicated in the table of analyses as 'alkalinity'. Calcium and magnesium carbonate cause hardness in water, which may be partly removed by boiling. Sodium carbonate causes softness in waters, and is referred to under 'Sodium' above.

Bicarbonates (HCO_3). Carbon dioxide dissolved in water renders the insoluble calcium and magnesium carbonates soluble as bicarbonates. The latter are decomposed by boiling the water, which changes them to insoluble carbonates.

Hardness is a condition imparted to waters chiefly by dissolved calcium and magnesium compounds. It here refers to the soap-destroying power of water, that is, to the amount of soap that must first be used to precipitate the above compounds before a lather is produced. The hardness of water in its original state is its total hardness, and is classified as 'permanent hardness' and 'temporary hardness'. Permanent hardness remains after the water has been boiled. It is caused by mineral salts that cannot be removed from solution by boiling, but it can be reduced by treating the water with natural softeners, such as ammonia or sodium carbonate, or with many manufactured softeners. Temporary hardness can be eliminated by boiling, and is due to the presence of bicarbonates of calcium and magnesium. Waters containing large quantities of sodium carbonate and small amounts of calcium and magnesium compounds are soft, but if the latter compounds present in large quantities the water is hard. The following table[1] m be used to indicate the degree of hardness of a water:

[1]Thresh, J.C., and Beale, J.F.: The Examination of Waters and Water Supplies; London, 1925, p. 21.

Total Hardness

Parts per million	Character
0-50	Very soft
50-100	Moderately soft
100-150	Slightly hard
150-200	Moderately hard
200-300	Hard
300 +	Very hard

The above table gives the generally accepted figures for hardness, but the people of southwestern Manitoba have become accustomed to harder waters, and the following table, based on about 800 field determinations of hardness, by the soap method, is more applicable:

Parts per million	Character
0-100	Very soft
100-150	Soft
150-250	Moderately hard
250-350	Hard
350-500	Very hard
500+	Excessively hard

Waters having a hardness of up to 300 parts per million are commonly used for laundry purposes. In southwestern Manitoba, hardness ranges from less than 50 parts per million to more than 2,500 parts per million.

PART II

TOWNSHIPS 1 TO 6, RANGES 10 TO 13, WEST PRINCIPAL MERIDIAN, MANITOBA

(Pilot Mound Area)

Introduction

An investigation of the ground-water resources of tps. 1 to 6, rges. 10 to 13, W. Princ. mer., was carried on by the writer during the field season of 1951. The account and map of the glacial geology were supplied by J. A. Elson.

Physical Features

The twenty-four townships investigated are a part of the upland just west of Pembina Mountain of the Manitoba escarpment. The surface slopes westward from the east side of the area at about 1,600 feet above sea-level and north from the International Boundary at around 1,550 feet, to the northwest corner, which stands at about 1,240 feet. In general the north half of the area is rolling, with 50 to 250 feet of relief, and the south half undulating, with about 20 feet of relief.

Geology

Table of Formations

Age	Formation	Character	Thickness (feet)
Recent	Alluvium	Stream-laid mud, silt, sand, and gravel	
Pleistocene	Glacial drift	Till, clay, boulders; assorted sand and gravel in outwash plains and eskers	0-100
Upper Cretaceous	Riding Mountain	Upper beds of medium to light grey, hard, siliceous shale (Odanah shale), with some thin layers of fine, blue sand and bentonite beds; lower beds of slippery clay shale that tend to slump	500 ±

Upper Cretaceous shales of the Riding Mountain formation underlie the Recent and Glacial deposits of the entire area but outcrop only along the sides of Pembina Valley, and of Rock and Pembina Lakes. The total thickness of the Riding Mountain formation is more than 1,000 feet but only the lower 400 feet or so are present in this area. The beds outcropping are the Odanah shale, a lithologic phase of the Riding Mountain formation and they consist of hard, siliceous, grey shale with a slight greenish cast when dry. In freshly exposed cuts the shale appears somewhat massive, but quickly weathers into fissile fragments. The hard siliceous phases, in places, are interbedded with softer bentonitic shale. The shales comprising Odanah beds characteristically show purple staining and numerous purple-stained concretions are irregularly distributed throughout the unit. The basal part of the Riding Mountain formation in this area is a clay shale that tends to slump. For further information on the bedrock geology, the reader is referred to the report of Wickenden.[1]

The bedrock surface slopes northwest, as does the topography. Numerous drumlinoid hills are present in the north half of the area and a few also in the south, notably Pilot Mound and Nebogwawin Butte.

The valley of Pembina River crosses the area from west to east, from the west side of tp. 3, rge. 13, swinging northeast to tp. 5, rge. 11, and then southeast to near the northeast corner of tp. 3, rge. 10. The flat valley floor is from 130 feet below the adjacent land surface in the west to about 250 feet in the east. Alluvial fans from streams made dams across the valley to form Rock Lake, Pembina Lake, and a small lake in sec. 29, tp. 4, rge. 10.

The surficial deposits in the northern part of the area are made up of about equal parts of end moraine, ground moraine, outwash, and silt. The end moraine is an interrupted belt of hummocky till and displaced bedrock extending east through tp. 4, rges. 13 to 10, and north into tp. 5, rges. 10 and 12; and north of this a plexus of hummocky till and ice-contact

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[1] Wickenden, R.T.D.: Mesozoic Stratigraphy of the Eastern Plains, Manitoba and Saskatchewan; Geol. Surv., Canada, Mem. 239, 1945.

drift deposits. There are numerous eskers and kame-like deposits within the area of end moraine. Outwash deposits of sand, gravel, and silt, from 2 to 10 feet thick, and areas of poorly sorted silt that may be partly aeolian in origin also occur locally. The ground moraine is a layer, 2 to 20 feet thick, of till overlying bedrock and the presence of many streamlined bosses (drumlinoids) indicate that the last continental glacier in this area moved towards the southeast. Small areas of clay and sand of deltaic or lake origin cover much of the north part of tp. 6, rge. 13, and here there is also an alluvial fan deposited by Cypress River. This alluvium is a poorly sorted silt, sand, and clay with some gravel containing shale pebbles. The gravel forms the bottom third of the alluvium deposit, which is at least 10 feet thick, and also some deposits perhaps formed along channels. A buried soil profile is situated 2 to 4 feet below the surface and this contains fossil oak logs, peat, and clam shells.

The thickness of the drift in the north half of the area is variable; the ground moraine is from a few inches to 20 feet thick and the end moraine and stratified drift are at least 100 feet thick. Most of the smooth hills have a core of bedrock (Odanah shale) but some are poorly sorted sand and gravel.

In the south half of the area, tps. 1 and 3, rges. 10 to 13, and tp. 4, rge. 10, the glacial and recent deposits are from 10 to 30 feet thick and they are on the average thicker in the west than in the east side. The deposits are about equal areas of ground moraine, silt, and outwash. There is washboard moraine in tp. 2, rge. 13. Ground moraine underlies both the silt and outwash and consists of a sheet of sandy-silty till up to 25 feet thick. It has a weathered buff appearance at the surface and the colour grades downward into grey at about 15 feet and below that depth clay is abundant. The silt deposits are thin, varying from 1 foot to 5 feet, and contain abundant sand and clay. This material probably was laid down in local ponds dammed by glacial ice but some may

be partly of aeolian origin. The outwash deposits are from 2 to 20 feet thick and include gravel, found mainly along the Pembina Valley, and sand and silt elsewhere. The washboard moraine in tp. 2, rge. 13, and vicinity is in the form of a series of discontinuous northeast trending ridges from 10 to 30 feet high and spaced at intervals of about 500 feet. Undrained depressions are abundant and though the ridges are sandy to silty till, the material below them is the typical ground moraine of the area.

Locally layers of boulders occur within the till. In these the boulders have their upper surfaces flattened and striated and probably were concentrated during an interglacial period of subaerial erosion. This boulder pavement at most exposures is between a sandy-clayey till below and a sandy to silty till above.

Eskers are widespread throughout the area. They are interrupted ridges of sand and shaly gravel up to a maximum of 30 feet high and 200 feet wide. Those in the south half of the area are generally less than 10 feet high and about a mile long. The sand and gravel may extend down into the till a few feet; in North Dakota stratified material has been found in the gaps in the eskers. Most eskers though apt to be shallow are nevertheless sources of ground water. Eskers in the north part of the area are generally somewhat larger than those in the south and are on top of other bodies of stratified drift. Many are on high ground, and there, are too well drained to be good aquifers.

Water Supply

Part of the precipitation falling as rain or snow runs off the surface to Pembina River and thence to Red River and the sea. Part of the precipitation percolates through the till to the surface of the bedrock where it moves laterally along the bedrock surface and some penetrates fractures in the bedrock. In its downward and lateral movements the water dissolves sulphates and carbonates from certain minerals in the

overburden and the bedrock. The dissolved sulphates of calcium and magnesium give the water an alkali taste.

Aquifers of the Riding Mountain formation are the best source of ground water. Bored wells, with diameters of 8 to 24 inches, at 50 feet or less in depth reach these sources in those areas where the thickness of the overburden is only from 1 foot to 30 feet. Deeper wells, 2 to 8 inches in diameter, may tap aquifers in which the water is under sufficient pressure to rise to points within 25 feet of the surface. Drilled wells, 200 feet or more in depth, tap aquifers in the bedrock that yield water carrying dissolved sodium, sulphate, and bicarbonate. Although these impart a bitter taste, the water is softer than that from shallower bedrock aquifers.

Most aquifers in the till are penetrated by dug wells less than 20 feet deep and from 4 to 6 feet in diameter. These provide a large wall area for infiltration of water and a large storage space for it between periods of pumping. Such wells yield from 2 to 10 gallons of water a minute and are equipped with hand pumps, though a few are equipped with small gasoline or electrically powered pumps. In recent years many owners have installed large capacity pumps and storage systems on these wells. Due to the abundance of rainfall in the period 1947-53 the supply has been maintained, but in dry seasons the large capacity pumps withdraw water faster than it can seep from the till into the well.

Lenses of sand or gravel in the till commonly yield sufficient water to supply a farm. These stratified deposits are limited in thickness and extent and are termed 'gravel streaks' or 'pockets' by drillers. They receive water from the till and make it more readily available to the well.

Permeable gravel and sand of outwash plains provide excellent ground water supplies that can be tapped by sandpoints.

Dugouts or dams are not required in this area as sufficient ground water for domestic and farm use is available even in years of limited rainfall.

Township 1, Range 10. The surface of the township is flat to uneven with the exception of three isolated hills, one of which, Nebogwawin Butte, rises approximately 100 feet above the surrounding area.

A supply of hard, clear water is available from fractured zones in bedrock that is overlain by overburden from 2 to 40 feet thick. Nine of the 57 wells recorded yield soft water.

The overburden is slightly permeable and yields water slowly. An excellent supply of potable ground water is present within a boulder pavement at the base of the overburden in sections 24 and 26.

Township 1, Range 11. The nearly flat to uneven surface of this township reflects the bedrock surface covered by from 8 to 30 feet of overburden. Long River crosses sections 6 and 7.

Wells dug, bored, or drilled to or into bedrock obtain an abundant supply of fresh water at depths of less than 150 feet. The quality of this water is variable but commonly the water from deep wells is softer. The shallow aquifers yield water that is alkali and unsatisfactory for domestic use but beneficial for stock.

In SW.$\frac{1}{4}$ sec. 18, three wells were drilled. One penetrated blue 'clay' and broken shale of the Riding Mountain formation to reach an aquifer at a depth of 318 feet that yields hard, clear water under sufficient pressure to rise in the well to within 14 feet of the surface. A second well, 300 feet distant, reached, at 270 feet, an aquifer of broken shale and gravel, within the Riding Mountain formation. This aquifer yields water of good quality that rises in the well to a point 14 feet from the surface of the ground. The third well, 208 feet deep, yields soft water.

Township 1, Range 12. The surface of the township is flat to uneven. Long River crosses the eastern part, entering in section 12 and leaving in section 35.

Ground moraine, which varies in thickness from 10 to 35 feet,

covers most of the township. Local patches of outwash and ice-contact stratified drift are excellent aquifers that can be reached by shallow-dug wells. Elsewhere the glacial deposits are unsatisfactory as a source of ground water.

The bedrock is the principal aquifer and wells drilled or bored into it yield a supply of water sufficient for 30 head of stock or more. These wells range in depth from 16 to 120 feet.

Forty-eight wells are recorded for the township. Eight yield soft water and these reach aquifers at depths of 100 feet or more in the bedrock.

Township 1, Range 13. The township is largely covered by ground moraine and outwash. The surface is rolling to uneven in the former case and flat to uneven in the outwash areas.

For a supply of ground water wells can be dug, bored, or drilled to the bedrock through from 10 to 35 feet of overburden, or drilled into bedrock never over 75 feet. Nine wells yield soft water. They are in the south part of the township where the overburden is pervious and allows for the direct percolation of the rainfall through it into the shale. Elsewhere the less pervious materials retard the movement of the ground water, which in its slower downward movement absorbs more salts from the overburden.

In the north part of the township the quality of the ground water is suitable for domestic and stock use except in those wells bordering the slough lands of sections 21, 22, 23, 26 and 27. Here slough waters percolate the shale to contaminate the wells.

Township 2, Range 10. The common aquifer of this township is the broken and fractured shale that underlies 8 to 20 feet of ground moraine and outwash silt deposits. Wells are dug to depths of 50 feet or less and each farm has a domestic well and a stock well.

In SE.$\frac{1}{4}$ sec. 34, 2 wells drilled 100 feet deep penetrate blue clay and yield just enough water for 15 head of stock. Test holes bored 60 to 110 feet deep in NW.$\frac{1}{4}$ sec. 25, reached aquifers in which the water was too alkali to use.

Wells drilled to depths of from 125 to 175 feet in sections 9 and 27, respectively, yield soft water.

Township 2, Range 11. The surface of the township is uneven to hilly, with isolated hills rising 35 to 50 feet above the surrounding plain. Two branches of the intermittent Crystal Creek cross the southwest quarter of the township.

The chief aquifer, the bedrock, is overlain by overburden that varies in thickness from 1 foot to 40 feet. An abundant supply of hard, clear, slightly alkali water is available from an aquifer at an average depth of 75 feet from the surface of the ground. Each farm has a domestic well and one or more stock wells.

Township 2, Range 12. Long River crosses the township from section 2 to section 31 in a valley from 1,000 to 2,000 feet wide and 25 to 30 feet deep cut through the overburden and into bedrock. Crystal Creek crosses the township from section 13 to section 34 in a valley from 2,000 to 4,000 feet wide and 10 to 15 feet deep. Both streams flow north.

Although outwash gravels cover most of the township, they are not of economic importance as aquifers. Wells are dug, bored, or drilled into the bedrock, where an abundant supply of hard, clear water is obtained. These wells are commonly less than 50 feet deep but others are recorded that are 80, 100, and 150 feet deep.

A well drilled 290 feet deep, in SE.$\frac{1}{4}$ sec. 5, yields water under sufficient pressure to rise in the well to a point 40 feet from the surface. The water has a total hardness of 172 parts per million. Of the total 3,890 parts per million of dissolved solids 2,952 are sodium chloride. Therefore, the water is salty and although soft it is not satisfactory for laundry as the sodium chloride destroys the cleaning quality of the soap.

Township 2, Range 13. The surface of the township is rolling. The south half is largely covered with ground moraine and elsewhere end moraine and outwash gravels mantle the bedrock. The surface deposits vary in thickness from 20 to 50 feet. A sufficient supply of hard, alkali water is

obtained from aquifers in the bedrock that are reached by boring to depths of 40 to 80 feet.

In NE.$\frac{1}{4}$ sec. 26, a well drilled 205 feet deep yields an abundant supply of soft water that is under sufficient pressure to rise in the casing to a point 40 feet from the surface of the ground.

Township 3, Range 10. The surface of this township is rolling. Pembina River follows a valley 200 feet deep and approximately 1 mile wide across the northeast quarter of the township.

Ground moraine, from 5 to 25 feet thick, overlies the bedrock. It is an aquifer in sections 2, 3, 4, 5, 11, and 12, where wells 18 to 24 feet deep supply a sufficient quantity of hard, clear water from gravel and sand lenses. The ground moraine in the north part of the township is largely covered by outwash sand and gravel that is too thin to be of any consequence as an aquifer. Here wells are bored or drilled 60 to 80 feet into the bedrock. An abundant supply of potable water is available from such wells but those under 60 feet in depth fail during periods of drought.

In SE.$\frac{1}{4}$ sec. 23, a well 200 feet deep yields approximately 30 gallons of water a day, but the water is soft and sufficient for domestic needs.

Township 3, Range 11. Pilot Mound, a bedrock cored hill covered with ground moraine, rises 80 to 100 feet above the surrounding uneven to level plain of the township. The southeast part of the township is covered by a clayey silt, probably of outwash origin. The remainder of the township is covered by outwash sand and gravel except an area of end moraine along the north margin.

A sufficient supply of water is available from the shale underlying the overburden. Wells in the west half of the township are dug 25 to 30 feet deep whereas in the east half deeper bored wells are common.

Township 3, Range 12. Pembina River crosses the township in a broad valley about 1 mile wide and with walls rising 100 feet or more above the flat floor, and these are gullied by short streams.

The bedrock is mantled by outwash deposits that vary in thickness from 7 to 45 feet. North of the river outwash gravel and ice-contact stratified drift are excellent aquifers and there wells are dug from 18 to 50 feet deep. Sandpoints are also used where possible. Elsewhere a sufficient supply of hard, clear water is obtained from wells dug or bored 28 to 120 feet into bedrock.

Township 3, Range 13. Rock Lake occupies that part of Pembina Valley that crosses this township from section 18 to section 12.

North of Rock Lake an abundant supply of medium hard, clear water is obtained from outwash deposits of sand and gravel in which wells are dug or driven to less than 30 feet.

Ground water pumped from the bedrock in this township is commonly alkali. Drilled wells are 125, 285, 170, and 137 feet deep in sections 1, 2, 6, and 8. In NE.$\frac{1}{4}$ sec. 13, a well drilled 123 feet reached a zone of sand at 118 feet below till. The water in this sand was under sufficient pressure to rise to the surface and overflow at a rate of 7 gallons a minute. In section 36 two wells drilled 110 and 176 feet deep, respectively, yield alkali water sufficient for 30 head of stock.

Township 4, Range 10. The broad valley of Pembina River crosses the township from section 31 to section 2. Wells are dug or bored through 10 to 25 feet of overburden to fractured bedrock. If the supply from this aquifer is limited, the wells are deepened on an average less than 50 feet. The water is hard, slightly alkali, and sufficient for domestic and stock needs.

Township 4, Range 11. Pembina Lake occupies that part of Pembina Valley crossing the northwest quarter of the township. The surficial deposits are largely sands and silts except for an area of end moraine in the southeast quarter, and ground moraine in the west part.

The chief aquifer is the bedrock, and a sufficient supply of hard, clear water is obtained from wells bored into it to depths of 25 to 100 feet. Local patches of sand or gravel yield a limited supply of water for domestic needs but such wells are not common.

Township 4, Range 12. Pembina River crosses the township from section 2 to section 24 and an intermittent tributary crosses the northwest quarter of the township to enter the Pembina in section 24.

Ice-contact stratified drift and lenses and pockets of gravel in the overburden are local but excellent aquifers. Where these are lacking wells dug less than 40 feet deep and to the surface of the shale yield an abundance of hard, clear water.

Aquifers at depths of 95 and 90 feet in the bedrock were encountered by wells drilled in sections 9 and 16 respectively.

Township 4, Range 13. The surface of this township is uneven to hilly with undrained depressions, some of which are filled with water, covering 3 or 4 acres of land.

The thickness of the overburden is variable, in the northeast quarter bedrock lies within 45 feet of the surface whereas in section 1 a test hole penetrated 106 feet of blue clay. Wells are commonly dug into ridges, lenses, or layers of sand and gravel. These wells are less than 40 feet deep and supply sufficient hard, clear water for domestic and stock needs.

Township 5, Range 10. Ground and end moraine with outwash sand and silt cover this township. The surface is irregular with elongate ridges and drumlin-like hills. The thickness of the overburden varies from 10 to 20 feet and is underlain by shale.

The chief aquifers are in the fractured surface of the bedrock. Wells are bored 20 to 50 feet deep to the bedrock and a sufficient supply of hard, clear water is pumped from them. All farms in this township have adequate water from this source.

Township 5, Range 11. The greater part of this township is included in Swan Lake Indian Reserve No. 7. The surface is rolling, with extensive wooded areas.

Water is available from the bedrock, which is reached by wells dug or bored 15 to 75 feet. The deeper wells yield alkali water.

Township 5, Range 12. The surface of this township is rolling to hilly, with abandoned channels and undrained depressions.

Throughout the township a sufficient supply of water is obtained from shallow wells that are on the average 25 feet deep. These wells reach aquifers in the overburden or the fractured surface of the bedrock. A few wells have been bored 75 to 80 feet deep but in them the water encountered was alkali and hard.

Township 5, Range 13. Numerous sloughs and wooded areas are common in the north half of this township, which is largely covered by end moraine. The south half is more even being an area of ice-contact stratified drift and outwash gravel, sand, and silt.

Bedrock lies within 10 feet of the surface in section 6 whereas in section 23 a well penetrated 65 feet of overburden. A supply of ground water is available at the contact of the overburden and the bedrock.

Township 6, Range 10. This township lies within the Tiger Hills. Undrained basins lie at irregular intervals between the hills and drainage channels of intermittent streams cross the township affording natural drainage for run-off.

Wells dug to the bedrock yield an adequate supply of hard, clear water from local and widespread aquifers. Some wells penetrate the bedrock but throughout the township they are less than 60 feet deep.

Township 6, Range 11. This township lies within the Tiger Hills, a belt of wooded hills 100 to 200 feet high, and intervening undrained basins and marsh lands. Cypress River crosses the south part of the township.

The township is largely covered by ground moraine with outwash sand and gravel and ice-contact stratified drift. These are excellent aquifers that supply much of the ground water to the farms of the township. Elsewhere wells are dug or bored to the bedrock where an abundant supply of water is encountered at depths of from 20 to 86 feet.

Township 6, Range 12. The surface of this township is rolling to hilly. Ground moraine with associated ice-contact stratified drift largely covers the bedrock, which has been moulded into drumlin-like hills. Cypress River crosses the township, flowing west from section 2 to section 18 and then north to section 31.

Wells are dug less than 40 feet into either lenses of gravel in the ground moraine or ice-contact stratified drift. Where bedrock is within 20 feet of the surface a sufficient supply of water is obtained from shallow wells dug into it.

In NW.$\frac{1}{4}$ sec. 8 and NW.$\frac{1}{4}$ sec. 10, wells drilled from 107 and 120 feet deep yield alkali water from the bedrock.

Township 6, Range 13. The surface of the township is uneven to flat except a rolling to hilly tract of ground moraine in the south part.

In the north part which is largely covered by an alluvial fan deposited by Cypress River, wells are dug less than 40 feet into sand that yields an abundant supply of hard, clear water. Sandpoints are also used. In the area of ground moraine patches of outwash gravel or lenses of sand are the most favourable aquifers. However, some wells dug from 35 to 50 feet to bedrock yield alkali water.

In NW.$\frac{1}{4}$ sec. 12, a limited supply of water, 15 to 20 gallons a day, is obtained by pumping two wells, one 127 feet deep and the other 107 feet deep.

Discussion of Analyses

A general discussion of water analyses will be found on page 5 of this report. Thirty samples of ground water from the Pilot Mound area were analysed by the Industrial Waters Section, Mines Branch, Department of Mines and Technical Surveys, Ottawa.

No standards for the chemical composition of potable waters have been established in Canada. In the United States, however, the need for federal control of the quality of water used by interstate water carriers

led to the establishment by the American Public Health Service of the following partial list of chemical standards.

Chemical constituent	Maximum concentration permitted (parts per million)
Dissolved solids	500, (1,000 permitted if necessary)
Chloride (Cl)	250
Sulphate (SO_4)	250
Magnesium (Mg)	125
Fluoride (F)	1.5
Iron and manganese	0.3

The 30 analyses included in this report fail to show any correlation between the chemical character of the water and the aquifer from which it was taken, except possibly in the case of magnesium. The concentration of magnesium in the waters from the deeper aquifers is notably less than in the case of the shallower aquifers. Also the non-carbonate hardness is negligible in the case of the deeper aquifers and the waters are softer.

That the character of the ground water within the same aquifer varies considerably even in short distances is illustrated by the analyses for samples NW. 24-2-12 and SE. 25-2-12 (See Table of Analyses of Ground Waters). These samples were collected from wells in Crystal City, Man., owned by J. E. Montgomery and N. E. Gorrell respectively. The wells are 82 and 85 feet deep, respectively, and reach the same aquifer.

ANALYSES OF GROUND WATERS FROM Tps. 1 to 6, Rges, 10 to 13, W. Princ. mer. Man. (Pilot Mound Area)

								Hardness (as $CaCO_3$) (pts. per million)			Constituents as analysed (parts per million)										
¼	Section	Township	Range	Meridian	Depth of well (feet)	Aquifer[x]	Conductance (micromhos 25°C)	Carbonate	Noncarbonate	Total	Alkalinity (as $CaCO_3$)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Silica (SiO_2)	Ammonia (NH_4)
SE	21	1	10	WPM	41	sh.	3368	372.0	54.6	426.6	372.0	89.7	49.3	628.0	453.8	1042.0	81.0	1.20	263.6	28.9	
SW	31	2	10	"	128	sh.	7205	496.4	9.1	505.5	496.4	140.8	37.5	1324.0	605.6	7.4	2118.0	0.20	20.0	26.0	
SE	34	2	10	"	100	bc.	7854	340.0	1182.4	1522.4	340.0	233.6	228.4	1136.0	414.8	509.5	2259.0	0.32	10.0	8.3	
SW	33	3	10	"	122	sh.	3751	87.8	0.0	87.8	763.2	23.0	7.4	792.0	931.1	577.8	446.4	0.32	15.2	15.3	
SW	36	4	10	"	35	sh.	2681	364.8	229.1	593.9	364.8	168.4	42.0	392.0	445.1	861.8	49.8	0.80	266.0	26.0	trace
SW	15	5	10	"	54	sh.	1460	373.6	484.5	858.1	373.6	208.1	82.0	13.2	455.8	381.8	25.2	0.00	80.0	26.0	
SW	27	5	10	"	38	sh.	3625	257.6	1251.4	1509.0	257.6	366.4	144.6	199.6	314.3	424.6	312.2	1.00	848.0	27.5	trace
NW	30	5	10	"	75	sh.	1670	221.6	388.1	609.7	221.6	87.4	95.1	98.0	270.4	74.0	118.0	0.00	467.2	25.3	0.8
NW	31	5	10	"	60	sh.	1586	307.0	317.0	624.0	307.0	169.0	49.2	102.8	374.5	134.2	152.0	0.40	252.0	31.5	
SE	15	6	10	"	22	sh.	1806	536.0	375.0	911.0	536.0	201.2	99.4	66.1	653.9	119.4	84.0	0.60	325.0	24.3	
SW	18	1	11	"	270	gr.	2738	430.5	0.0	430.5	458.0	128.3	26.7	466.5	558.8	481.5	357.0	0.20	5.0	21.0	
NW	13	3	11	"	45	sh.	3928	284.0	1104.9	1388.9	284.0	375.2	110.0	491.0	346.5	1684.0	200.0	1.20	170.0	27.5	
NE	8	4	11	"	25	sh.	1811	226.8	519.3	746.1	226.8	207.1	55.8	163.4	276.7	822.2	11.0	0.00	4.0		
SW	10	4	11	"	30	sh.	1421	400.0	71.4	471.4	400.0	104.9	51.0	147.4	488.0	172.0	57.0	0.20	160.0	25.5	
NE	22	4	11	"	68	sh.	1894	62.0	0.0	62.0	509.2	18.4	3.9	421.0	621.2	482.2	3.6	0.00	5.7	26.8	
NW	23	4	11	"	96	sh.	1901	45.9	0.0	45.9	586.0	13.6	2.9	441.0	714.9	422.2	5.5	0.60	6.0	23.8	
SW	27	4	11	"	80	sh.	3444	160.3	0.0	160.3	724.8	48.4	9.6	795.0	884.3	843.6	196.0	0.00	11.6		

x - Symbols used for aquifers: sh. - shale, Riding Mountain formation.
gr. - gravel, layer of gravel or sand in the Riding Mountain formation.
bc. - blue clay, glacial drift.

ANALYSES OF GROUND WATERS FROM Tps. 1 to 6, Rges. 10 to 13, W. Princ. mer. Man. (Pilot Mound Area)

								Hardness (as $CaCO_3$) (pts. per million)			Constituents as analysed (parts per million)										
¼	Section	Township	Range	Meridian	Depth of well (feet)	Aquifer[x]	Conductance (micromhos 25°C)	Carbonate	Noncarbonate	Total	Alkalinity (as $CaCO_3$)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Silica (SiO_2)	Ammonia (NH_4)
NW	33	1	12	WPM	112	sh.	4291	105.4	0.0	105.4	523.0	108.0	31.9	848.0	638.1	784.4	676.0		7.0	27.3	
SE	5	2	12	"	290	sh.	6978	172.4	0.0	172.4	631.6	42.9	15.9	1516.0	770.6	5.0	1962.0		0.0	23.5	6.7
SE	6	2	12	"	40	sh.	8486	499.0	[illegible]	1353.3	499.0	311.0	140.4	1860.0	608.8	4491.4	109.0		65.2	28.8	trace
NW	24	2	12	"	82	sh.	2925	65.8	0.0	65.8	612.0	18.8	4.6	672.0	746.6	311.2	404.4	0.4	4.5	25.0	
SE	25	2	12	"	85	sh.	1536	328.0	0.0	328.0	344.0	87.8	26.5	239.2	419.7	430.4	36.6	0.4	4.0	20.5	
SE	7	4	12	"	41	sh.	3344	371.0	0.0	371.0	505.2	79.7	41.9	742.0	616.3	1321.0	11.4	0.6	0.0	25.8	1.8
SW	20	1	13	"	28	sh.	4157	481.0	908.0	1389.0	481.0	210.0	210.4	456.0	586.8	633.8	352.0		103.0	28.5	trace
NW	29	1	13	"	74	sh.	2498	462.0	363.1	825.1	462.0	202.0	78.1	345.0	563.6	991.8	46.8	0.6	2.5	26.8	trace
SE	36	1	13	"	90	sh.	2810	151.0	0.0	151.0	602.0	36.6	14.5	644.0	734.4	582.7	216.0		13.5	28.5	
SW	6	2	13	"	61	sh.	6224	488.0	0.0	488.0	604.8	110.9	51.4	1456.0	737.9	2392.6	330.0		0.0	20.5	5.2
NE	26	2	13	"	205	sh.	5690	118.8	0.0	118.8	820.0	29.8	10.8	1220.0	1000.4	4.2	1416.0	0.2	0.0	22.5	5.5
SW	1	3	13	"	125	sh.	3872	611.0	1415.0	2026.0	610.8	227.0	354.7	324.2	745.2	1945.8	35.4	0.6	3.0	24.8	2.8
SW	2	3	13	"	285	sh.	4286	400.3	0.0	400.3	523.0	108.0	31.9	848.0	638.1	784.4	676.0		7.0	27.3	

x - Symbols used for aquifers: sh. - shale, Riding Mountain formation.

Sample SW. 6-2-13 was taken from a bored well in Mather, Man., owned by A. L. Fulford. The analysis showed a concentration of 1430.0 ppm. sodium and 2392.6 ppm. sulphate. These constituents combine to produce sodium sulphate, which crystallizes from the water as the hydrate, Glauber's Salt. Needle-shaped crystals of Glauber's Salt line the inside of the wooden cribbing during wet seasons and rapidly dry and fall as a powder during drier seasons. Glauber's Salt is also commonly seen as a white precipitate on and near watering troughs.

The presence of nitrate in ground water may indicate organic contamination. It is recommended that water containing more than 45 ppm. of nitrate should not be used in feeding infants because of the danger of infant cyanosis (methemoglobinemia), resulting in the so-called blue baby.

The presence of fluoride in drinking water in excess of 1.5 ppm. may cause mottling of the enamel of teeth in young children, but fluoride in concentrations less than 1 ppm. is regarded by many as beneficial to the development of the teeth.

Record of Wells

The following table of well records has been prepared from drillers' records and data collected by the Geological Survey of Canada. The following abbreviations are used:

Sec.	Section
Drl.	Drilled well
Brd.	Bored well
Drn.	Driven well (sandpoint)
R.M.	Riding Mountain formation
Dom.	Domestic use
Stk.	Stock use
Not	Not used
Mun.	Municipal use
#	Well from which sample was taken

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 1 Range 10

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Dug	1,563	28	13	14	RM	Hard	Dom. Stk.	Sufficient supply
2	NE	Dug	1,584	28	7	12	RM	Hard	Dom. Stk.	Also three dug wells
3	NE	Brd.	1,592	85	16	-	RM	Hard	Dom. Stk.	Sufficient supply
4	NW	Dug	1,558	30	5	-	RM	Hard	Dom. Stk.	" "
5	SE	Dug	1,553	14	-	-	Sand	Hard	Dom. Stk.	" "
6	NE	Brd.	1,555	55	11	-	RM	Hard	Dom. Stk.	" for 30 head
7	NW	Dug	1,575	30	-	-	RM	Hard	Dom. Stk.	Also a dug well 30 ft. deep
8	NW	Drl.	1,589	99	25	-	RM	Hard	Dom. Stk.	Also a well 100 feet deep
9	SW	Brd.	1,558	45	30	-	RM	Hard	Dom. Stk.	Sufficient for 20 head
10	NE	Brd.	1,591	180	90	-	RM	Soft	Dom. Stk.	" " 40 "
12	NE	Dug	1,563	40	12	-	RM	Hard	Dom. Stk.	Sufficient supply
13	NE	Drl.	1,566	175	20	-	RM	Hard	Dom. Stk.	Water at 91 feet.
15	NE	Brd.	1,593	35	20	-	RM	Hard	Dom. Stk.	Sufficient for 40 head
16	NW	Drl.	1,604	140	20	-	RM	Soft	Dom. Stk.	Sufficient supply.
17	NE	Dug	1,585	25	5	-	RM	Hard	Stk.	Sufficient for 60 head
18	SW	Brd.	1,576	28	12	2	RM	Hard	Dom. Stk.	" " 15 "
19	NE	Dug	1,564	22	10	-	RM	Hard	Dom. Stk.	" " 15 "
21	SE	Brd.	1,587	41	17	-	RM	Hard	Dom. Stk.	Sufficient supply
22	NW	Brd.	1,613	90	40	10	RM	Hard	Dom. Stk.	Sufficient for 70 head
23	SE	Drl.	1,573	35	5	-	RM	Hard		New well
24	SE	Drl.	1,552	100	16	-	RM	Hard	Dom.	Also a bored well 85ft. deep for stock
26	NE	Brd.	1,568	38	-	-	Till	Hard	Dom. Stk.	Water in zone of boulders at 33 feet
28	SE	Dug	1,553	22	10	4	RM	Hard	Dom. Stk.	Sufficient for 5 head only
29	NW	Brd.	1,607	57	35	-	RM	Hard	Dom.	Sufficient supply
31	NW	Brd.	1,557	45	20	-	RM	Hard	Dom. Stk.	" "
32	NW	Brd.	1,565	100	12	-	RM	Hard	Stk.	Also a well dug 16 feet
33	SE	Brd.	1,573	30	10	-	RM	Soft	Dom.	
34	NE	Brd.	1,577	42	18	-	RM	Hard	Stk.	
35	NW	Drl.	1,579	60	18	18	RM	Hard	Dom. Stk.	Usually sufficient for 30 head
36	NE	Brd.	1,574	60	19	-	RM	Hard	Dom. Stk.	Sufficient for 30 head only

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 1 Range 11

Sec.	¼	Type of well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Brd.	1,570	30	10	-	-	Hard	Dom. Stk.	Sufficient supply
2	NW	Brd.	1,563	42	20	24	RM	Hard	Dom. Stk.	" "
3	NW	Brd.	1,577	35	14	-	RM	Hard	Dom.	" "
4	SW	Brd.	1,563	92	11	-	RM	Hard	Stk.	Sufficient for 40 head
5	NW	Brd.	1,546	36	12	-	-	Hard	Stk.	Alkali water.
6	SE	Brd.	1,526	78	54	-	RM	Hard	Stk.	
8	SW	Brd.	1,547	33	12	-	RM	Hard	Dom. Stk.	Sufficient for 40 head
10	NE	Brd.	1,585	85	30	20	RM	Hard	Dom. Stk.	Sufficient supply
11	NE	Drl.	1,573	175	30	-	RM	Soft	Dom. Stk.	" "
13	SE	Drl.	1,573	86	12	20	RM	Hard	Dom. Stk.	" "
14	NW	Brd.	1,566	60	20	25	RM	Hard	Dom. Stk.	Sufficient for 50 head
15	SW	Brd.	1,572	56	17	-	RM	Hard	Dom. Stk.	" " 30 "
16	SE	Brd.	1,559	75	30	-	RM	Soft	Dom. Stk.	" " 20 "
17	NW	Brd.	1,553	40	15	-	RM	Hard	Stk.	" " 30 "
18	SW	Drl.	1,516	270	15	-	-	Hard	Dom.	Drawdown 40 feet
20	SE	Brd.	1,550	60	13	10	RM	Soft	Stk.	Also a drilled well over 150 feet deep
21	NW	Brd.	1,546	60	12	8	RM	Hard	Dom. Stk.	
22	NE	Brd.	1,572	70	44		RM	Hard	Dom. Stk.	Sufficient for 50 head
23	NW	Brd.	1,573	39	12	-	-	Hard	Dom.	
24	SE	Brd.	1,518	34	9	-	-	Hard	Dom. Stk.	Sufficient supply
25	SE	Dug	1,544	10	3	-	Gravel	Hard	Dom.	
26	NW	Brd.	1,569	80	20	-	RM	Hard	Dom. Stk.	Sufficient for 80 head
27	SW	Brd.	1,543	40	20	-	RM	Hard	Dom. Stk.	" " 25 "
28	NE	Brd.	1,540	52	20	-	RM	Hard	Dom. Stk.	" " 40 "
29	SW	Brd.	1,533	40	-	-	RM	Hard	Dom. Stk.	" " 50 "
30	NE	Brd.	1,537	35	25	32	RM	Hard	Dom. Stk.	Sufficient supply
31	SE	Brd.	1,544	72	38	8	RM	Hard	Dom.	Also a stock well 90 feet deep
32	NE	Brd.	1,477	38	21	-	RM	Hard	Dom. Stk.	Sufficient supply
35	NW	Drl.	1,546	28	-	-	RM	Hard	Dom.	Well at Eton School
36	NW	Brd.	1,554	39	17	-	-	Hard	Dom. Stk.	

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 1, Range 12

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
2	NE	Brd.	1,553	66	17	-	RM	Hard	Dom. Stk.	Sufficient supply
4	SE	Brd.	1,557	68	23	-	RM	Hard	Dom. Stk.	Sufficient for 10 head
6	NE	Brd.	1,569	35	6	-	RM	Hard	Stk.	Sufficient supply
7	NW	Brd.	1,564	45	20	35	RM	Hard	Dom. Stk.	Sufficient for 25 head
10	NW	Drl.	1,546	113	12	-	RM	Soft	Dom. Stk.	Sufficient supply
12	NE	Drl.	1,516	100	13	-	RM	Hard	Dom. Stk.	Also a well 47 feet deep
13	NW	Dug	1,516	21	12	18	RM	Hard	Dom. Stk.	Sufficient supply
14	NE	Drl.	1,516	107	27	-	RM	Soft	Dom. Stk.	" "
16	NE	Brd.	1,532	40	20	-	RM	Hard	Dom. Stk.	Sufficient for 25 head
17	NE	Brd.	1,551	59	18	-	RM	Hard	Dom. Stk.	Temperature of water 42°F
18	NE	Brd.	1,551	60	-	-	RM	Hard	Dom. Stk.	Sufficient for 35 head
19	NE	Brd.	1,545	120	7	-	-	Soft	Dom. Stk.	Sufficient supply
20	SE	Brd.	1,540	55	10	-	RM	Hard	Dom. Stk.	Sufficient for 20 head
21	NE	Brd.	1,539	30	12	18	RM	Hard	Dom. Stk.	Sufficient supply
22	SW	Brd.	1,533	50	15	-	RM	Hard	Dom. Stk.	" "
23	NE	Brd.	1,516	40	32	-	Till	Hard	Dom. Stk.	" "
24	NE	Brd.	1,508	28	-	-	RM	Hard	Dom.	Stock well 40 feet deep
25	SW	Drl.	1,519	16	12	10	RM	Hard	Dom. Stk.	Sufficient supply
27	SE	Brd.	1,518	44	17	-	-	Hard	Dom. Stk.	" "
28	NW	Brd.	1,524	40	18	-	RM	Hard	-	Alkali water
29	NW	Brd.	1,536	46	19	-	RM	Hard	Dom. Stk.	Temperature of water 39°F
30	NE	Brd.	1,536	42	12	-	-	Hard	Not	
31	SE	Brd.	1,543	60	45	-	RM	Hard	Dom. Stk.	Sufficient Supply
32	NE	Brd.	1,518	46		-	RM	Hard	Dom. Stk.	350 gals. a day (approx.)
33	NW	Drl.	1,519	112	30	-	RM	Hard	Dom. Stk.	Sufficient for 45 head
34	SW	Brd.	1,513	40	14	-	RM	Hard	Stk.	House well 23 feet deep
35	NW	Brd.	1,495	90	-	-	RM	Hard	Dom. Stk.	Sufficient supply
36	NW	Drl.	1,504	75	20	-	RM	Soft	Dom.	Stock well 70 feet deep

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 1, Range 13

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Brd.	1,608	65	12	9	RM	Soft	Dom. Stk.	Sufficient supply
4	NW	Brd.	1,563	50	25	-	RM	Soft	Dom. Stk.	Sufficient for 30 head
5	NW	Brd.	1,544	56	10	-	RM	Hard	Dom. Stk.	Sufficient supply
6	NW	Drl.	1,551	200	20	32	RM	Soft	Dom. Stk.	Sufficient for 70 head
7	NE	Drl.	1,549	32	20	-	-	Hard	Stk.	" " 30 "
8	NW	Dug	1,554	16	12	-	Drift	Hard	Dom.	Sufficient supply
9	NW	Drl.	1,549	140	20	20	RM	Soft	Stk.	Sufficient for 30 head
10	NW	Drl.	1,572	187	40	15	RM	Soft	Dom. Stk.	Sufficient supply
11	NW	Brd.	1,570	53	12	18	RM	Soft	Stk.	
12	NE	Brd.	1,569	142	30	-	RM	Hard	Dom. Stk.	" "
14	NW	Brd.	1,566	60	15	-	RM	Hard	Stk.	House well 40 feet deep
15	SW	Brd.	1,560	45	16	6	RM	Hard	Dom. Stk.	Sufficient for 35 head only
16	NW	Brd.	1,552	43	12	-	RM	Hard	Dom.	
17	SE	Dug	1,541	25	9	-	RM	Hard	Dom.	
18	NW	Brd.	1,536	37	15	33	RM	Hard	Not	Also a well 35 feet deep
19	NW	Dug	1,525	17	4	-	Drift	Hard	Dom. Stk.	Sufficient for 40 head
20	SW	Dug	1,539	28	16			Hard	Dom. Stk.	Sufficient supply
23	NW	Brd.	1,547	40	8	-	-	Hard	Not	Also a well 60 feet deep
24	SW	Brd.	1,567	75	45	-	RM	Hard	Dom. Stk.	Sufficient for 100 head
27	NE	Brd.	1,552	60	20	-	RM	Hard	Dom. Stk.	" " 25 "
28	NW	Brd.	1,549	63	40	-	RM	Hard	Dom. Stk.	Sufficient supply
29	NW	Drl.	1,543	74	16	-	RM	Hard	Not	Also a well 85 feet deep
30	NE	Dug	1,532	46	15	15	RM	Hard	Dom. Stk.	Sufficient for 30 head
31	NE	Dug	1,525	38	11	14	RM	Hard	Dom. Stk.	" " 40 "
32	SW	Brd.	1,521	60	40		RM	Hard	Dom. Stk.	" " 30 " only
33	SW	Brd.	1,536	76	14	60	RM	Hard	Dom. Stk.	Sufficient supply
34	SE	Brd.	1,549	63	16		RM	Hard	Dom. Stk.	Sufficient for 30 head only
35	NW	Brd.	1,548	70	30	-	RM	Hard	Dom. Stk.	Sufficient supply
36	SE	Drl.	1,547	90	40	-	RM	Hard	Dom.	

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 2, Range 10

Sec	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SW	Drl.	1,573	100	25	-	RM	Soft	Dom.	Stock well 80 feet deep
2	SW	Brd.	1,579	50	18	10	RM	Hard	Stk.	House well bored 45 feet
3	SE	Brd.	1,592	32	17	-	-	Hard	Not	
4	NE	Brd.	1,568	35	20	-	RM	Soft	Dom. Stk.	Sufficient for 40 head
5	SE	Dug	1,572	30	10	18	RM	Hard	Stk.	Sufficient for 40 head
6	NE	Brd.	1,570	50	18	15	RM	Hard	Dom. Stk.	Sufficient supply
7	SW	Brd.	1,574	48	18	13	RM	Hard	Dom. Stk.	Sufficient supply
9	SE	Drl.	1,560	175	40	-	RM	Soft	Dom. Stk.	Sufficient supply
10	SW	Brd.	1,568	30	10	-	RM	Hard	Stk.	Sufficient supply
12	SE	Brd.	1,564	73	20	12	RM	Hard	Dom. S	Stock well 24 feet deep
13	NE	Dug	1,588	25	9	-	-	Hard	Dom.	A dugout for stock
14	NW	Dug	1,565	45	35	-	--	Hard	Dom. Stk.	Sufficient for 20 head only
15	SE	Drl.	1,572	54	12	-	RM	Hard	Dom. Stk.	Sufficient supply
16	NE	Brd.	1,558	60	30	-	RM	Hard	Stk.	House well 28 feet deep
17	NE	Brd.	1,546	35	20	-	-	Hard	Dom. Stk.	Sufficient for 25 head
18	NE	Brd.	1,547	50	35	-	RM	Hard	Stk.	Alkali water
20	NW	Dug	1,549	27	20	-	RM	Hard	Dom. Stk.	Sufficient supply
21	SE	Dug	1,545	30	-	-	RM	Hard	Dom. Stk.	Sufficient for 30 head
22	NE	Brd.	1,559	18	10	-	Gravel	Hard	Dom.	Also a well 48 feet deep
26	SE	Brd.	1,568	75	10	-	RM	Hard	Not	Also a dug well 30 feet deep
27	SE	Drl.	1,560	122	4	-	RM	Soft	Dom.	Stock well 70 feet deep
28	SW	Dug	1,547	16	15	16	RM	Hard	Stk.	
29	NW	Brd.	1,563	43	20	-	RM	Hard	Dom. Stk.	Sufficient for 25 head
30	SW	Drl.	1,553	18	16	-	-	Hard	Dom.	Sufficient supply
31	SW	Drl.	1,543	128	20	-	RM	Hard	Dom. Stk.	Sufficient for 20 head
32	NE	Brd.	1,557	30	11	-	-	Hard	Dom.	Sufficient supply
33	NE	Brd.	1,548	50	20	18	RM	Hard	Dom. Stk.	Also a dug well 20 feet deep
34	SE	Drl.	1,558	100	15	-	Till	Hard	Dom.	Yields approx. 50 gals. per day
36	SW	Dug	1,557	13	8	-	-	Hard	Not	

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 2, Range 11

Sec.	¼	Type of Well	Elev. (Feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Brd.	1,562	46	11	-	RM	Hard	Dom. Stk.	Sufficient supply
2	NW	Brd.	1,551	35	27	1	RM	Hard	Dom. Stk.	Alkali water
4	NW	Brd.	1,513	50	-	-	-	Hard	Stk.	Used only in winter months
5	NE	Brd.	1,516	35	-	-	-	Hard	Dom. Stk.	
6	NW	Dug	1,516	25	17	-	RM	Hard	Dom. Stk.	Sufficient for 30 head
7	NE	Dug	1,507	35	12	-	RM	Hard	Dom.	Crystal Creek crosses farm
9	NW	Dug	1,511	35	-	-	RM	Hard	Stk.	House well 90 feet deep
10	SE	Brd.	1,548	25	18	-	RM	Hard	Dom.	Sufficient supply
11	SW	Brd.	1,545	26	13	-	RM	Hard	Dom. Stk.	Sufficient supply
12	SE	Brd.	1,570	47	19	-	RM	Hard	Dom. Stk.	Sufficient supply
14	NE	Brd.	1,543	30	15	15	RM	Hard	Dom.	Also a stock well 44 feet deep
15	NW	Brd.	1,556	50	15	10	RM	Hard	Not	
17	NE	Dug	1,515	28	25	27	RM	Hard	Dom.	Also a stock well 28 feet deep
18	NW	Brd.	1,512	18	5	-	RM	Hard	Stk.	
19	NW	Brd.	1,516	42	10	40	RM	Hard	Dom. Stk.	Sufficient supply
20	SW	Brd.	1,514	43	15	26	RM	Hard		Well dug in 1951
21	SE	Dug	1,531	24	9	-	-	Hard	Dom. Stk.	Sufficient supply
22	SW	Brd.	1,555	21	13	-	-	Hard	Dom.	
24	SW	Dug	1,539	47	7	-	-	Hard	Not	Also a stock well 26 feet deep
25	SW	Brd.	1,545	36	13	-	-	Hard	Dom.	Also a stock well 58 feet deep
26	SW	Brd.	1,549	65	-	-	RM	Hard	Stk.	Sufficient for 40 head
27	NW	Drl.	1,540	80	25	-	RM	Hard	Dom.	Sufficient supply
28	NE	Brd.	1,532	47	13	-	RM	Hard	Dom. Stk.	Sufficient supply
29	NW	Brd.	1,523	54	18	-	RM	Hard	Dom. Stk.	Sufficient supply
30	NW	Dug	1,486	45	32	3	RM	Hard	Stk.	Drilled well 70 feet deep
31	SW	Dug	1,519	80	25	3	RM	Hard	Stk.	Sufficient for 40 head
32	NE	Brd.	1,516	25	7	-	-	Hard	Stk.	Also a house well 20 feet deep
33	NE	Brd.	1,535	53	20	-	-	Hard	Dom. Stk.	Sufficient supply
34	SE	Drl.	1,545	70	-	-	RM	Hard	Dom.	Yields about 100 gallons a day
36	NE	Brd.	1,543	40	12	10	RM	Hard	Stk.	Also a well bored 50 feet

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 2, Range 12

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Drl.	1,515	35	14	7	RM	Soft	Dom.	Also a stock well bored 50 feet
2	SW	Brd.	1,596	80	-	-	RM	Hard	Dom. Stk.	
3	NW	Brd.	1,511	30	20	10	RM	Hard	Dom.	Also a well drilled 150 feet
4	SW	Brd.	1,519	100	35	-	RM	Hard	Dom. Stk.	Sufficient for 45 head
5	SE	Drl.	1,523	290	-	-	RM	Hard	Stk.	House well over 100 feet deep
6	SE	Brd.	1,518	40	10	40?	RM	Hard	Dom. Stk.	Sufficient supply
7	SE	Brd.	1,520	43	9	-	RM	Hard	Not	Well bored in 1951
8	SE	Dug	1,509	25	11	-	RM	Hard	Dom.	Also a stock well 41 feet deep
9	NW	Brd.	1,507	65	19	-	RM	Soft	Stk.	Sufficient for 20 head
12	NW	Brd.	1,523	66	15	5	RM	Hard	Dom. Stk.	Sufficient supply
13	SW	Brd.	1,518	80	60	-	RM	Hard	Stk.	Sufficient supply
14	SE	Brd.	1,513	100	20	-	RM	Hard	Stk.	Sufficient for 50 head
15	SW	Drl.	1,522	150	-	-	RM	Soft	Dom. Stk.	Dug several dry holes
16	SW	Dug	1,504	36	29	-		Hard	Not	Alkali water
17	SE	Brd.	1,486	50	-	8	RM	Hard	Stk.	Also a house well bored 37 feet
18	NW	Brd.	1,496	26	5	-	RM	Hard	Dom. Stk.	Two such wells
19	SE	Brd.	1,498	42	12	-	RM	Hard	Dom. Stk.	Sufficient supply
20	NW	Drl.	1,492	80	-	-	RM	Hard	Dom. Stk.	Sufficient for 20 head
21	NW	Brd.	1,501	42	27	-	-	Hard	Dom.	Sufficient supply
22	NE	Brd.	1,511	37	20	-	RM	Hard	Dom.	Also a stock well 35 feet deep
23	NE	Brd.	1,510	60	40	-	RM	Hard	Stk.	Water is salty; waters 15 head
24	NE	Brd.	1,503	70	20	20	RM	Hard	Stk.	Sufficient supply
26	NE	Brd.	1,524	56	40	-	Till	Hard	Dom. Stk.	
27	SW	Brd.	1,500	65	50	-	RM	Hard	Dom. Stk.	Sufficient supply
28	NW	Brd.	1,508	43	22	-	Till	Hard	Dom. Stk.	Sufficient supply
30	SW	Brd.	1,491	39	28	-	RM	Soft	Dom. Stk.	Well beside a creek
31	SW	Brd.	1,514	72	25	-	RM	Hard	Dom. Stk.	Sufficient for 200 head
32	SE	Brd.	1,509	42	17	41	RM	Hard	Dom. Stk.	Sufficient supply
33	NE	Brd.	1,518	40	35	-	RM	Hard	Dom. Stk.	Sufficient for 20 head
36	SE	Drl.	1,517	80	20	18	RM	Hard	Dom.	Also a stock well 40 feet deep

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 2, Range 13

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Brd.	1,535	55	20	-	RM	Hard	Dom.	Also a stock well bored 60 feet
2	SW	Brd.	1,543	40	15	-	RM	Hard	Stk.	Sufficient for 20 head
3	NE	Brd.	1,523	80	35	-	RM	Hard	Dom. Stk.	Sufficient for 40 head
4	NW	Drl.	1,545	56	20	12	RM	Hard	Dom. Stk.	Sufficient supply
5	NW	Brd.	1,527	40	15	--	RM	Hard	Dom. Stk.	Sufficient supply
6	SW	Brd.	1,519	55	25	12	RM	Hard	Dom.	
7	NE	Brd.	1,546	27	17	-	Sand	Hard	Stk.	Sufficient for 40 head
8	SE	Brd.	1,523	40	20	-	RM	Hard	Dom. Stk.	Sufficient for 30 head
10	SW	Brd.	1,530	52	16	-	RM	Hard	Not	
11	SW	Brd.	1,528	70	34	-	RM	Hard	Dom. Stk.	Sufficient supply
13	NE	Brd.	1,506	40	15	-	RM	Hard	Dom. Stk.	Sufficient for 15 head
15	NE	Dug	1,516	19	10	-	RM	Hard	Dom. Stk.	Sufficient for 25 head only
16	NE	Brd.	1,549	70	20	-	RM	Hard	Dom. Stk.	Sufficient supply
17	SE	Brd.	1,534	30	18	-	Till	Hard	Dom. Stk.	Sufficient for 25 head
18	NE	Brd.	1,534	50	20	-	-	Hard	Dom. Stk.	Sufficient for 30 head
19	SW	Drl.	1,533	104	20	-	RM	Soft	Dom. Stk.	Sufficient 40 head
22	NW	Drl.	1,518	80	18	22	RM	Soft	Dom.	Also a stock well 65 feet deep
24	NE	Drl.	1,594	50	20	-	RM	Hard	Dom. Stk.	Sufficieient supply
26	NE	Drl.	1,506	205	8	-	RM	Hard	Dom. Stk.	Also a dug well 52 feet deep
27	SE	Brd.	1,521	44	17	-		Hard	Dom. Stk.	
28	SE	Brd.	1,507	70		-	RM	Soft	Dom. Stk.	Sufficient for 100 head
29	NW	Brd.	1,527	71	24	-	RM	Hard		Sufficient supply
30	NW	Brd.	1,532	66	25	-	RM	Hard	Dom.	Well for stock 85 feet
32	NW	Brd.	1,522	80	60	-	RM	Hard	Dom. Stk.	Sufficient for 20 head only
33	SW	Brd.	1,525	56	25	-	RM	Hard	Dom.	Also a well 56 feet deep
34	SE	Brd.	1,527	60	45	-	-	Hard	Dom. Stk.	Sufficient for 40 head
35	NW	Brd.	1,508	47	20	-	RM	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 3, Range 10

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NW	Brd.	1,556	64	8	-		Hard	Stk.	Sufficient supply
2	NW	Brd.	1,551	20	-	-	Sand	Hard	Dom.	Stock well 24 feet deep
3	NW	Dug	1,547	18	8	-	-	Hard	Dom. Stk.	Sufficient supply
4	SW	Dug	1,559	23	20	-	Sand	Hard	Dom.	Well 32 feet deep for stock
5	NW	Drl.	1,562	200	27	20	RM	Soft	Dom. Stk.	Sufficient supply
6	SW	Brd.	1,549	22	18	12	RM	Hard	Dom.	Also stock well bored 70 feet
7	SW	Dug	1,545	14	-	-	RM	Hard	Dom. Stk.	Sufficient supply
8	SW	Brd.	1,583	110	40	-	RM	Hard	Dom. Stk.	Sufficient for 25 head
9	SE	Brd.	1,546	85	20	-	RM	Hard	Dom. Stk.	Sufficient for 35 head
10	SW	Dug	1,547	30	4	20	RM	Hard	Dom.	Stock well 45 feet deep
12	SE	Dug	1,550	25	20	-	Sand	Hard	Dom. Stk.	Abundant supply
13	SW	Brd.	1,540	60	40	-	RM	Hard	Stk.	Also a house well 12 feet deep
14	SW	Dug	1,563	28	17	-	-	Hard	Dom. Stk.	Sufficient supply
15	NW	Brd.	1,578	60	25	3	RM	Hard	Dom. Stk.	Sufficient for 40 head
16	NE	Brd.	1,541	20	10	5	RM	Hard	Dom.	Sufficient supply
17	SE	Brd.	1,548	96	48	-	RM	Hard	Stk.	Sufficient supply
19	SW	Dug	1,566	20	-	-	RM	Hard	Dom.	Also a stock well 200 feet
20	NE	Brd.	1,566	90	24	-	RM	Hard	-	Alkali water
21	NW	Brd.	1,575	80	25	-	RM	Hard	Dom. Stk.	Alkali water
22	SE	Dug	1,576	26	6	-	RM	Hard	Dom. Stk.	Sufficient supply
23	NW	Brd.	1,533	80	-	-	RM	Hard	Dom. Stk.	Sufficient supply
27	SE	Brd.	1,564	57	12	8	RM	Hard	Dom. Stk.	Sufficient supply
28	SE	Drl.	1,578	86	29	-	-	Hard	-	Water in gravel at 86 feet
29	SE	Drl.	1,578	70	-	-	RM	Hard	Dom. Stk.	Sufficient for 50 head only
30	SW	Drl.	1,547	195	40	-	RM	Hard	Stk.	Domestic well 21 feet
32	NE	Drl.	1,553	110	55	-	RM	Soft	- Stk.	Domestic well 24 feet
33	SW	Drl.	1,569	122	74	-	RM	-		
36	NW	Dug	1,532	69	30	-	Gravel	Hard	Dom. Stk.	
36	NE	Brd.	1,527	75	56	6	RM	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 3, Range 11

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Brd.	1,547	50	12	-	RM	Hard	Not	
2	SW	Brd.	1,516	49	8	-	RM	Hard	Stk.	
3	NE	Brd.	1,562	120	10	-	RM	Hard	Stk.	Sufficient supply
4	NW	Drl.	1,540	90	25	-	RM	Hard	Stk.	Also a bored well 35 feet
5	NE	Brd.	1,535	29	14	17	RM	Hard	Dom. Stk.	Sufficient supply
6	SE	Brd.	1,509	35	15	10	RM	Soft	Stk.	
7	NE	Dug	1,535	35	20	30	RM	Hard	Dom. Stk.	Sufficient supply
8	NE	Drl.	1,529	70	20	-	RM	Hard	Dom. Stk.	Also a dug well 15 feet deep
10	NE	Dug	1,530	23	7	-	RM	Hard	Dom. Stk.	
11	SW	Brd.	1,532	55	7	15	RM	Hard	Stk.	Also a well 21 feet deep
13	SE	Dug	1,553	22	16	16	RM	Hard	Dom. Stk.	Also a well 30 feet deep
15	NW	Brd.	1,526	29	16	-	-	Hard	Dom.	Sufficient supply
17	SW	Dug	1,524	32	22	-	RM	Hard	Dom.	Also a stock well 40 feet deep
18	SW	Dug	1,483	26	20	16	RM	Hard	Dom.	" " " " 40 " "
19	NE	Dug	1,491	25	14	-	RM	Hard	Dom.	Sufficient supply
20	SE	Brd.	1,561	50	40	-	RM	Hard	Dom. Stk.	" "
22	NW	Dug	1,538	30	25	-	-	Hard	Stk.	" for 25 head
24	NE	Drl.	1,547	100	32	-	RM	Hard	Stk.	Salty water
25	NE	Brd.	1,545	43	9	-	RM	Hard	Dom.	Sufficient supply
28	SE	Dug	1,524	21	14	-	-	Hard	Stk.	" "
29	NE	Dug	1,542	24	10	-	-	Hard	Dom. Stk.	Sufficient for 50 head
30	NW	Dug	1,529	25	20	-	RM	Hard	Dom.	Also a stock well 40 feet deep
31	SE	Drl.	1,522	30	20	-	RM	Hard	Dom. Stk.	Sufficient supply
32	NE	Dug	1,530	20	12	-	RM	Hard	Dom. Stk.	" "
33	SE	Brd.	1,551	38	20	-	RM	Hard	Dom. Stk.	Sufficient for 40 head
34	SW	Brd.	1,557	40	25	5	RM	Hard	Dom. Stk.	Sufficient supply
35	NE	Dug	1,546	25	14	-	Gravel	Hard	Dom. Stk.	" "
36	NW	Drl.	1,543	80	25	-	RM	Hard	Dom. Stk.	Three wells on farm

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 3, Range 12

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of Water	Use	Remarks
1	SW	Dug	1,514	56	53	-	-	Hard	Dom. Stk.	Aquifer of fine sand
2	NE	Brd.	1,534	28	18	-	RM	Hard	Dom. Stk.	Three wells on farm
3	NE	Dug	1,507	22	12	12	RM	Hard	Dom. Stk.	Sufficient supply
4	SW	Drl.	1,509	34	23	24	RM	Hard	Not	Well at Oak School
5	NE	Dug	1,479	16	14	-	Gravel	Hard	Dom. Stk.	Sufficient supply
9	NW	Dug	1,474	17	8	13	RM	Hard	Dom. Stk.	Sufficient supply
10	NE	Drl.	1,527	45	40	45	RM	Hard	Dom.	Also a stock well 45 feet deep
11	NW	Brd.	1,513	24	14	-	-	Hard	Not	
12	SE	Dug	1,521	20	17	8	RM	Hard	Dom.	Also a stock well 60 feet deep
14	SW	Dug	1,511	20	12	-	-	Hard	Dom. Stk.	Sufficient supply
18	NE	Dug	1,455	20	18	-	Gravel	Hard	Dom. Stk.	" "
19	SW	Brd.	1,477	24	20	-	Sand	Hard	Dom. Stk.	Also a sandpoint 22 feet deep
20	NW	Dug	1,466	18	-	-	Gravel	Hard	Dom. Stk.	Sufficient supply
21	SW	Dug	1,477	21	16	-	Gravel	Hard	Stk.	
22	SE	Dug	1,489	24	12	-	RM	Hard	Not	
23	SE	Brd.	1,495	30	18	-	RM	Hard	Dom.	Also a similar well for stock
24	SE	Brd.	1,487	22	17	-	RM	Hard	Dom.	Also a stock well 18 feet deep
26	NE	Drl.	1,459	85	30	-	RM	Soft	Stk.	House well 35 feet deep
28	SE	Drl.	1,450	120	30	-	RM	Soft	Dom. Stk.	Sufficient supply
30	NW	Dug	1,524	55	53	-	Till	Hard	Dom. Stk.	Sufficient supply
32	SE	Brd.	1,582	45	-	-	Till	Hard	Dom. Stk.	0-18 feet sand, 18-45 feet blue clay
33	SW	Brd.	1,491	35	30	-	Gravel	Hard	Dom. Stk.	Spring in ravine on section
35	NW	Brd.	1,438	12	6	-	-	Hard	Dom. Stk.	
36	NW	Dug	1,506	45	24	-	RM	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 3, Range 13

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of Water	Use	Remarks
1	SW	Brd.	1,510	125	70	-	RM	Hard	Dom. Stk.	Sufficient supply
2	SW	Drl.	1,498	285	57	-	RM	Hard	Dom. Stk.	" "
4	NW	Brd.	1,515	65	20	-	-	Soft	Dom. Stk.	" "
5	SW	Brd.	1,531	60	20	-	Sand	Hard	Dom. Stk.	Sufficient supply
6	NW	Drl.	1,530	170	50	-	RM	Hard	Dom.	A drilled well for stock
7	SE	Brd.	1,515	76	30	50	RM	Hard	Dom. Stk.	Sufficient supply
8	SW	Brd.	1,486	137	-	-	-	Hard		Well flowed
13	NE	Drl.		123	-	-	Sand	Hard		Formerly flowed 7 gals. per minute
20	NE	Drn.	1,485	20	-	-	Sand	Hard	Dom. Stk.	Sufficient supply
22	NW	Dug	1,480	15	5	-	Sand	Hard	Dom. Stk.	Sufficient supply
25	NE	Dug	1,504	35	30	-	Sand	Hard	Dom. Stk.	" "
27	NE	Drn.	1,485	13	-	-	Sand	Hard	Dom. Stk.	Sufficient for 40 head
30	NW	Dug	1,509	50	25	-	Sand	Hard	Dom. Stk.	Sufficient supply
31	SW	Dug	1,510	27	17	-	Drift	Hard	Dom. Stk.	" "
31	SE	Brd.	1,532	33	21	-	Drift	Hard	Dom. Stk.	" "
31	NE	Dug	1,560	57	48	-	Drift	Hard	Dom. Stk.	" "
32	SW	Dug	1,511	30	20	-	Drift	Hard	Dom. Stk.	" "
32	SE	Dug	1,514	38	32	38	RM	Hard	Dom. Stk.	" "
33	SW	Drn.	1,501	18	-	-	Sand	Hard	Dom. Stk.	Sufficient for 25 head
34	SE	Drn.	1,492	27	-	-	Sand	Hard	Dom. Stk.	Sufficient supply
36	SW	Drl.	1,522	110	40	-	-	Hard	Stk.	Sufficient for 30 head
36	SE	Drl.	1,538	176	-	-	-	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 4, Range 10

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of Water	Use	Remarks
1	SE	Brd.	1,509	45	20	-	RM	Hard	Dom. Stk.	Sufficient supply
4	SE	Brd.	1,534	113	63	-	RM	Hard	Dom. Stk.	" "
5	SW	Brd.	1,551	56	16	20	RM	Hard	Stk.	Also a bored well 45 feet deep
6	SW	Brd.	1,544	57	33	-	RM	Hard	Stk.	Sufficient supply
8	NW	Dug	1,497	24	20	-	Drift	Hard	Dom.	Also a dug well 20 feet deep
9	SE	Drl.	1,535	66	35	10	RM	Hard	Stk.	Sufficient for 40 head
9	NE	Brd.	1,512	80	25	-	RM	Hard	Stk.	Also a dug well 55 feet deep
10	NW	Drl.	1,547	120	30	-	RM	Hard	Stk.	Also a house well 60 feet deep
12	SE	Brd.	1,525	20	10	-	-	Hard	Dom.	
13	SE	Brd.	1,534	28	19	-	RM	Hard	Dom. Stk.	Sufficient supply
17	SW	Brd.	1,537	32	15	10	RM	Hard	Dom. Stk.	Sufficient supply
18	SW	Brd.	1,568	36	26	-	RM	Hard	Dom. Stk.	" "
20	SW	Dug	1,469	25	-	-	RM	Hard	Dom.	Also a well 22 feet deep for stock
22	NW	Brd.	1,534	30	-	-	RM	Hard	Dom. Stk.	Sufficient for 30 head
24	NE	Brd.	1,528	48	27	-	RM	Hard	Dom.	Sufficient supply
25	NW	Dug	1,581	45	25	-	RM	Hard	Dom. Stk.	Sufficient for 15 head only
26	NE	Brd.	1,566	35	-	-	-	Hard	Dom.	Also a drilled well
27	NE	Dug	1,546	10	6	10	RM	Hard	Stk.	
28	NE	Brd.	1,521	12	5	-	-	Hard	Dom. Stk.	Sufficient for 15 head
32	SE	Brd.	1,507	45	30	-	Drift	Hard	Dom. Stk.	Sufficient supply
33	NW	Brd.	1,543	21	9	-	Drift	Hard	Dom.	
34	NW	Brd.	1,543	20	16	-	RM	Hard	Dom.	Also a stock well 20 feet deep
34	SE	Drl.	1,553	29	8	10	RM	Hard	Dom.	Sufficient supply
35	NW	Brd.	1,587	56	30	-	RM	Hard	Dom. Stk.	Sufficient for 30 head
36	SW	Brd.	1,573	35	15	-	RM	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 4, Range 11

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of Water	Use	Remarks
1	SE	Dug	1,537	70	10	25	RM	Soft		Water has a sulphur odour
2	SE	Dug	1,552	13	7	-	Drift	Hard	Not	
3	NW	Brd.	1,553	53	31	-	RM	Hard	Dom. Stk.	Sufficient supply
4	NE	Brd.	1,537	36	14	-	-	Hard	Dom. Stk.	" "
6	SW	Brd.	1,506	38	9	37	RM	Hard	Dom. Stk.	Also a well 50 feet
8	NE	Brd.	1,505	25	5	-	RM	Hard	Dom. Stk.	Also a stock well dug 14 feet
9	SW	Brd.	1,522	25	-	10	RM	Hard	Dom. Stk.	Sufficient for 20 head
10	SW	Brd.	1,533	30	12	-	RM	Hard	Dom. Stk.	Sufficient supply
11	NW	Dug	1,538	43	11	-	-	Hard	Stk.	Sufficient for 30 head
12	SE	Brd.	1,531	88	14	48	RM	Hard	Dom. Stk.	Bored a dry hole 72 feet deep
13	SE	Brd.	1,577	56	44	50	RM	Hard	Dom. Stk.	Sufficient supply
14	SE	Dug	1,505	23	13	-	Sand	Hard	Dom. Stk.	" "
15	SW	Brd.	1,527	18	4	-	RM	Hard	Dom. Stk.	Waters 55 head of stock
16	NW	Brd.	1,548	43	15	-	RM	Hard	Stk.	Sufficient for 40 head
17	NE	Dug	1,545	25	15	5	RM	Hard	Dom. Stk.	Sufficient supply
18	SE	Drl.	1,502	69	57	-	RM	Hard	Dom. Stk.	
19	SE	Dug	1,513	11	7	-	RM	Hard	Dom.	Sufficient for 10 head only
20	SW	Dug	1,521	20	5	6	RM	Hard	Stk.	Sufficient for 50 head
21	SE	Brd.	1,538	24	16	10	RM	Hard	Dom.	- -
22	NE	Drl.	1,501	68	20	-	RM	Hard	Dom. Stk.	Sufficient supply
23	NW	Drl.	1,497	96	40	-	RM	Soft	Dom. Stk.	" "
24	NW	Dug	1,479	18	5	-	Sand	Hard	Dom. Stk.	Also a dug well 11 feet deep
25	SW	Dug	1,474	30	15	-	Sand	Hard	Dom. Stk.	Sufficient supply
26	NE	Dug	1,473	27	8	-	RM	Hard	Dom. Stk.	" "
27	SW	Drl.	1,501	80	-	-	RM	Hard	Dom. Stk.	" "
28	SW	Drl.	1,516	100	25	30	RM	Soft	Dom. Stk.	" "
29	SW	Brd.	1,511	84	30	-	RM	Hard	Dom. Stk.	.
30	SE	Dug	1,508	22	19	18	RM	Hard	Dom.	Sufficient supply
34	SE	Dug	1,487	19	14	-	Sand	Hard	Dom.	Stock well 34 feet deep
35	NW	Dug	1,470	12	-	-	RM	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 4, Range 12

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Brd.	1,491	54	16	-	Sand	Hard	Dom. Stk.	Sufficient for 40 head only
3	NW	Dug	1,482	8	-	-	Drift	Hard	Dom. Stk.	Sufficient supply
4	NE	Dug	1,532	25	-	-	Gravel	Hard	Dom. Stk.	
5	NE	Dug	1,514	22	18	-	Drift	Hard	Dom. Stk.	Sufficient supply
6	SE	Drl.	1,487	41	6	-	Drift	Hard	Dom. Stk.	Also a dug well 32 feet deep
7	SE	Brd.	1,473	41	11	39	RM	Hard	Dom. Stk.	Sufficient supply
8	SE	Dug	1,493	37	15	-	-	Hard	Dom. Stk.	Sufficient for 25 head
9	NE	Drl.	1,547	95	33	-	RM	Hard	Dom.	Drilled well for stock
10	SW	Brd.	1,533	40	21	-	-	Hard	Dom. Stk.	Sufficient supply
12	SE	Brd.	1,589	22	10	-	Drift	Hard	Dom.	Also a well 21 feet deep
15	NW	Dug	1,491	32	20	-	Till	Hard	Dom. Stk.	Sufficient supply
16	SE	Drl.	1,511	90	-	-	-	Hard	Dom. Stk.	Alkali water
17	SE	Dug	1,475	13	8	-	Drift	Hard	Stk.	Drilled well at house
18	SE	Drl.	1,459	70	20	-	-	Hard	Dom. Stk.	Sufficient for 30 head
19	SW	Brd.	1,454	44	14	-	-	Hard	Not	Two other such wells
20	NE	Drl.	1,440	60	35	32	RM	Hard	Stk.	Two other dug wells near creek
21	SE	Dug	1,468	24	14	-	Drift	Hard	Dom. Stk.	Sufficient supply
22	NW	Dug	1,483	22	18	-	Drift	Hard	Dom. Stk.	Sufficient for 50 head
22	NW	Brd.	1,477	32	15	-	-	Hard	Dom.	Well at Dry River School
25	NW	Dug	1,478	10	5	-	Drift	Hard	Dom. Stk.	Sufficient supply
26	NW	Brd.	1,490	93	45	-	RM	Hard	Stk.	Also a house well 30 feet deep
27	NW	Dug	1,462	55	40	-	Drift	Hard	Dom. Stk.	Sufficient supply
30	SE	Brd.	1,443	65	30	-	RM	Hard	Dom. Stk.	Sufficient for 60 head
32	NE	Dug	1,461	36	33	-	RM	Hard	Dom. Stk.	Sufficient supply
33	NE	Dug	1,460	25	10	-	Drift	Hard	Dom. Stk.	Sufficient supply
34	NW	Dug	1,501	23	18	16	RM	Hard	Dom. Stk.	Sufficient supply
35	NE	Dug	1,498	20	6	-	Drift	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 4, Range 13

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SW	Dug	1,479	12	6	-	Sand	Hard	Dom. Stk.	
2	NE	Dug	1,474	33	20	-	Till	Hard	Dom. Stk.	Three other dug wells 33 feet deep
3	SE	Dug	1,488	10	3	-	Till	Hard	Dom. Stk.	Sufficient supply
5	NW	Dug	1,524	30	22	-	Till	Hard	Dom. Stk.	Sufficient supply
8	NE	Dug	1,451	18	8	-	Till	Hard	Dom. Stk.	Sufficient supply
9	SE	Dug	1,450	12	-	-	Drift	Hard	Dom. Stk.	Sufficient supply
10	SW	Dug	1,457	12	7	-	Gravel	Hard	Dom. Stk.	Two dug wells
11	NE	Dug	1,457	12	4	-	Till	Hard	Dom. Stk.	Sufficient supply
12	SE	Dug	1,455	13	7	-	Till	Hard	Dom.	Sufficient supply
13	SW	Dug	1,459	22	20	-	Sand	Hard	Dom.	Also a stock well 15 feet deep
14	NE	Dug	1,460	32	25	-	Drift	Hard	Dom.	Also a stock well 12 feet deep
15	NE	Dug	1,453	34	25	-	Till	Hard	Dom. Stk.	Sufficient supply
16	SW	Brd.	1,441	50	17	-	Till	Hard	Dom. Stk.	Sufficient supply
21	SE	Brd.	1,441	20	10	-	Gravel	Hard	Dom. Stk.	Sufficient supply
22	NW	Brd.	1,442	28	14	-	Till	Hard	Dom. Stk.	Sufficient supply
24	NE	Dug	1,433	42	17	30	RM	Hard	Dom. Stk.	Sufficient supply
25	SE	Drl.	1,433	100	15	-	RM	Hard	Dom. Stk.	Sufficient for 40 head
26	SW	Dug	1,439	45	15	45	RM	Hard	Dom. Stk.	Sufficient supply
27	SW	Dug	1,436	20	-	-	Drift	Hard	Dom.	Stock well 60 feet deep
29	SW	Dug	1,436	31	20	-	Drift	Hard	Dom. Stk.	Sufficient supply
30	NW	Dug	1,419	8	4	-	Drift	Hard	Dom. Stk.	Sufficient supply
31	SW	Dug	1,427	16	12	-	Sand	Hard	Dom. Stk.	Sufficient supply
32	NW	Dug	1,424	13	10	-	Drift	Hard	Dom. Stk.	Nitrate contamination
33	NW	Dug	1,422	14	7	-	Drift	Hard	Dom. Stk.	Sufficient supply
34	NW	Dug	1,428	33	20	-	Sand	Hard	Dom. Stk.	Sufficient for 15 head only
35	NW	Brd.	1,421	60	30	-	RM	Hard	Stk.	Sufficient for 50 head
36	SE	Brd.	1,436	50	20	-	RM	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 5, Range 10

Sec.	1/4	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Brd.	1,572	40	20	-	RM	Hard	Dom. Stk.	Sufficient supply
3	NE	Dug	1,600	35	21	36	Drift	Hard	Stk.	Also a house well 36 feet deep
4	NE	Brd.	1,568	52	32	-	RM	Hard	Dom. Stk.	Sufficient supply
6	SW	Dug	1,531	40	20	-	RM	Hard	Dom.	Also a stock well 40 feet deep
8	SW	Dug	1,535	40	35	-	RM	Hard	Dom.	Also a stock well 40 feet deep
9	SW	Brd.	1,527	36	21	22	RM	Hard	Dom. Stk.	Sufficient supply
10	NE	Brd.	1,571	30	13	-	Drift	Hard	Dom.	Sufficient supply
11	NW	Brd.	1,578	32	13	-	-	Hard	Dom.	Bertram school well
12	SE	Dug	1,581	44	25	-	Drift	Hard	Stk.	Alkali water
13	NE	Brd.	1,554	30	28	-	RM	Hard	Dom. Stk.	Three wells on farm
15	SW	Brd.	1,566	54	37	-	-	Hard	Dom. Stk.	
16	NE	Dug	1,591	32	16	-	RM	Hard	Dom. Stk.	Bored a well 90 feet
19	NW	Brd.	1,548	60	50	-	RM	Hard	Dom. Stk.	Sufficient for 20 head
20	SW	Dug	1,572	30	24	10	RM	Hard	Dom. Stk.	Sufficient supply
21	SW	Dug	1,571	13	6	8	RM	Hard	Dom.	Sufficient supply
22	NW	Dug	1,624	24	12	-	-	Hard	Dom.	Sufficient supply
23	NW	Dug	1,560	16	10	-	RM	Hard	Dom. Stk.	Sufficient supply
24	SE	Dug	1,560	80	30	-	RM	Hard	Dom. Stk.	Sufficient for 25 head
25	NE	Dug	1,543	20	14	6	RM	Hard	Dom. Stk.	Also a well dug 18 feet deep
27	SE	Brd.	1,576	38	18	-	RM	Hard	Stk.	
28	NW	Dug	1,644	38	12	-	RM	Hard	Dom.	A bored well 111 feet deep
29	SW	Dug	1,575	48	18	-	RM	Hard	Dom. Stk.	Sufficient for 30 head
30	NW	Brd.	1,581	75	30	14	RM	Hard	Dom. Stk.	Sufficient supply
31	NW	Brd.	1,590	60	35	10	RM	Hard	Dom. Stk.	Sufficient supply
32	SE	Dug	1,624	22	12	-	RM	Hard	Dom. Stk.	Also a well 68 feet deep
34	SW	Dug	1,541	34	30	-	RM	Hard	Dom. Stk.	Sufficient supply
35	SE	Brd.	1,545	60	20	-	RM	Hard	Dom. Stk.	Sufficient supply
36	SE	Dug	1,538	25	20	-	RM	Hard	Dom. Stk.	Also a well 60 feet deep

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

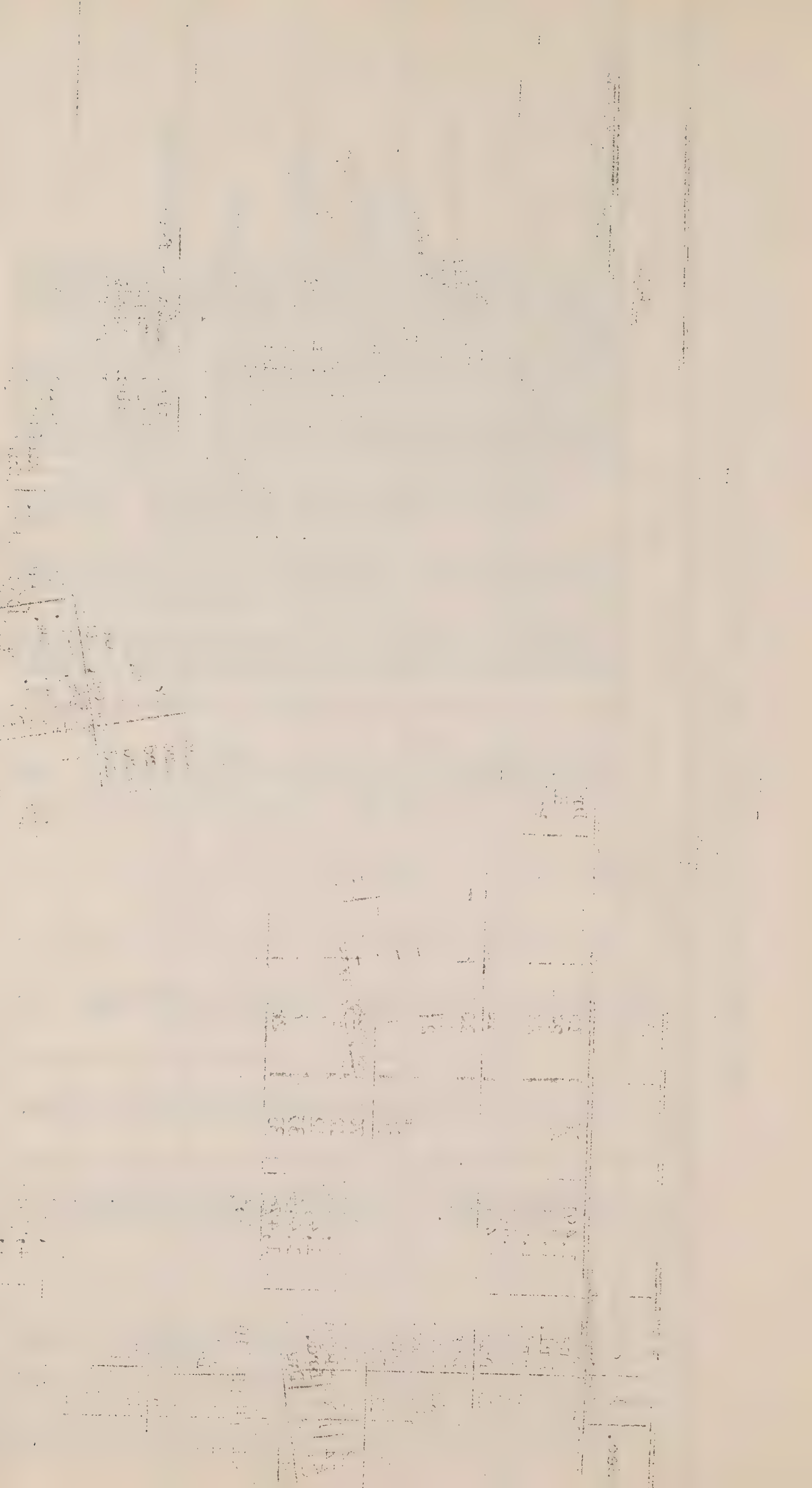
Township 5, Range 11

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
7	SW	Brd.	1,553	67	45	-	RM	Hard	Dom.	Sufficient supply
12	SE	Brd.	1,494	50	30	-	RM	Hard	Dom. Stk.	Sufficient for 40 head
13	SW	Brd.	1,505	30	20	-	Drift	Hard	Dom. Stk.	Sufficient supply
13	NW	Dug	1,465	18	15	-	RM	Hard	Dom. Stk.	Sufficient supply
18	SE	Dug	1,488	24	15	-	Drift	Hard	Dom. Stk.	Sufficient supply
19	NE	Dug	1,497	26	23	-	RM	Hard	Dom. Stk.	Sufficient supply
24	NW	Dug	1,499	16	14	-	RM	Hard	Dom.	Also a stock well dug 32 feet deep
25	SE	Dug	1,534	14	12	-	RM	Hard	Dom. Stk.	Sufficient for 15 head
25	NE	Dug	1,523	35	17	-	RM	Hard	Dom.	Also a stock well 25 feet deep
26	SW	Dug	1,512	25	22	-	RM	Hard	Dom. Stk.	Also a dug well 18 feet deep
27	NW	Dug	1,498	21	18	-	-	Hard	Dom.	Sufficient supply
28	NW	Brd.	1,513	50	45	-	Drift	Hard	Dom. Stk.	Sufficient for 10 head
29	SW	Dug	1,516	41	38	7	RM	Hard	Dom. Stk.	Sufficient supply
31	SW	Dug	1,437	63	58	30	RM	Hard	Dom.	Two wells
31	NW	Dug	1,438	15	13	-	RM	Hard	Dom. Stk.	Also a well dug 22 feet deep
33	NW	Dug	1,489	42	32	40	RM	Hard	Dom. Stk.	Sufficient supply
34	SW	Dug	1,517	45	40	-	Sand	Hard	Dom. Stk.	Sufficient supply
35	SE	Dug	1,544	75	-	30	RM	Hard	Stk.	Two other wells 20 and 40 feet deep
36	SW	Dug	1,537	18	10	-	-	Hard	Dom. Stk.	Sufficient supply
36	NE	Brd.	1,551	17	9	-	RM	Hard	Dom.	Also a stock well 24 feet deep

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 5, Range 12

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	NW	Dug	1,491	16	10	30	Drift	Hard	Dom.	Also a stock well bored 80 feet deep
2	NE	Drl.	1,498	68	24	-	RM	Hard	Dom.	Well at Mariapolis Hotel
3	SE	Brd.	1,496	21	12	-	Drift	Hard	Dom. Stk.	Sufficient supply
3	NW	Dug	1,476	22	10	-	Till	Hard	Dom. Stk.	Sufficient for 25 head
4	NE	Dug	1,496	14	10	-	Sand	Hard	Dom. Stk.	Sufficient supply
5	NW	Dug	1,434	32	10	-	Drift	Hard	Dom. Stk.	Sufficient supply
6	NW	Drl.	1,420	45	30	-	Till	Hard	Dom. Stk.	Sufficient supply
8	SW	Brd.	1,462	40	20	-	Drift	Hard	Dom. Stk.	Also a dug well 30 feet deep
10	SW	Dug	1,467	15	12	-	Drift	Hard	Dom. Stk.	Sufficient supply
11	NE	Dug	1,492	10	8	-	Drift	Hard	Stk.	Sufficient for 10 head
12	SW	Brd.	1,513	70	26	30	RM	Hard	Dom. Stk.	Poor quality water
14	NE	Dug	1,480	12	10	-	Gravel	Hard	Dom. Stk.	Sufficient for 50 head
16	SE	Dug	1,467	12	7	-	RM	Hard	Dom. Stk.	Sufficient supply
17	NW	Brd.	1,483	35	8	-	RM	Hard	Dom. Stk.	Sufficient supply
18	SE	Dug	1,478	33	28	-	Till	Hard	Dom. Stk.	Sufficient for 25 head only
21	SE	Dug	1,443	21	11	-	-	Hard	Dom. Stk.	Sufficient supply
22	NW	Dug	1,430	26	16	-	RM	Hard	Dom. Stk.	Sufficient supply
23	SW	Dug	1,477	15	10	-	Till	Hard	Dom. Stk.	Sufficient for 15 head
24	SE	Dug	1,514	20	10	-	Drift	Hard	Dom. Stk.	Sufficient supply
26	NW	Dug	1,448	35	33	-	RM	Hard	Dom. Stk.	
27	NE	Dug	1,433	24	15	-	-	Hard	Dom. Stk.	Two other wells 24 feet deep
28	NW	Dug	1,386	12	7	-	RM	Hard	Dom. Stk.	Sufficient supply
29	SE	Dug	1,413	25	14	-	RM	Hard	Dom.	Sufficient supply
30	NW	Dug	1,394	32	28	-	Drift	Hard	Dom. Stk.	Sufficient supply
31	NW	Dug	1,397	25	18	-	-	Hard	Dom. Stk.	Sufficient supply
32	SE	Dug	1,383	30	-	-	-	Hard	Dom. Stk.	Sufficient supply
33	NE	Brd.	1,421	56	39	-	RM	Hard	Dom. Stk.	Sufficient supply
34	NW	Dug	1,365	12	9	-	RM	Hard	Dom. Stk.	Sufficient supply



REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 5, Range 13

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
2	NE	Brd.	1,410	22	18	20	RM	Hard	Dom.	Well at Greenway Store
2	NE	Brd.	1,410	86	36	-	RM	Hard	-	Well at Greenway Rink
3	SE	Dug	1,427	21	11	-	-	Hard	Dom. Stk.	Not sufficient in dry years
4	NW	Dug	1,425	15	7	-	-	Hard	Dom. Stk.	Sufficient for 50 head only
5	SW	Dug	1,426	20	7	-	Drift	Hard	Dom.	Also a stock well
6	SW	Dug	1,422	30	10	10	RM	Hard	Stk.	Also a house well dug 25 feet deep
7	NW	Dug	1,413	25	15	-	RM	Hard	Dom. Stk.	Sufficient supply
8	NW	Brd.	1,411	21	8	-	RM	Hard	Dom. Stk.	Four other wells on farm
10	NW	Brd.	1,416	46	36	-	RM	Hard	Dom. Stk.	Sufficient supply
12	NW	Dug	1,400	20	18	-	-	Hard	Dom. Stk.	Sufficient supply
14	SE	Dug	1,398	20	8	16	RM	Hard	Dom. Stk.	Sufficient for 50 head
15	SE	Brd.	1,433	40	30	-	RM	Hard	Dom. Stk.	
16	SW	Dug	1,420	20	12	-	Sand	Hard	Dom. Stk.	Sufficient for 20 head
17	SE	Dug	1,406	20	9	-	-	Hard	Dom. Stk.	Three other wells on farm
18	SE	Dug	1,409	22	15	-	Gravel	Hard	Dom.	Two other wells 24 and 37 feet deep
20	SW	Dug	1,403	14	9	-	RM	Hard	Dom. Stk.	Sufficient supply
22	NE	Dug	1,371	39	31	-	-	Hard	Dom.	
23	SE	Dug	1,379	20	12	-	Sand	Hard	Dom. Stk.	Drilled another well 100 feet; soft water
24	NW	Brd.	1,464	25	16	-	RM	Hard	Dom. Stk.	Sufficient supply
27	NW	Brd.	1,348	24	8	-	-	Hard	Stk.	Sufficient for 20 head
28	SW	Dug	1,377	25	13	-	Gravel	Hard	Dom. Stk.	Sufficient supply
34	SW	Brd.	1,405	54	40	-	RM	Hard	Dom. Stk.	Sufficient supply
35	SW	Dug	1,374	20	15	-	RM	Hard	Dom. Stk.	Sufficient supply
36	NW	Dug	1,364	25	15	-	Drift	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 6, Range 10

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
2	SE	Dug	1,530	40	15	-	RM	Hard	Dom. Stk.	Also a well 18 feet deep
3	SW	Dug	1,528	26	22	18	RM	Hard	Dom.	Sufficient supply
4	SE	Brd.	1,529	42	20	18	RM	Hard	Stk.	Sufficient supply
5	SW	Dug	1,601	37	15	-	RM	Hard	Dom. Stk.	Three other wells on farm
8	SE	Brd.	1,511	16	14	10	RM	Hard	Dom. Stk.	Also a well 25 feet deep
9	NW	Brd.	1,512	31	-	-	RM	Hard	Dom. Stk.	
10	SE	Dug	1,529	40	31	-	RM	Hard	Dom. Stk.	Sufficient supply
11	NE	Dug	1,580	32	12	15	RM	Hard	Dom. Stk.	Also a well 21 feet deep
12	NW	Dug	1,537	40	10	-	RM	Hard	Dom. Stk.	Sufficient supply
13	NE	Dug	1,533	13	7	-	-	Hard	Dom. Stk.	Three other wells on farm
15	SE	Dug	1,516	22	16	-	RM	Hard	Dom. Stk.	Sufficient supply
16	SW	Dug	1,494	13	11	12	RM	Hard	Dom. Stk.	Sufficient supply
17	NE	Dug	1,547	28	12	-	Drift	Hard	Dom. Stk.	Sufficient for 15 head only
18	NW	Dug	1,510	32	25	-	RM	Hard	Dom. Stk.	Sufficient supply
19	SW	Dug	1,560	10	2	-	Gravel	Hard	Dom. Stk.	Sufficient supply
20	NW	Dug	1,454	28	12	-	Till	Hard	Dom. Stk.	Sufficient for 20 head
22	NE	Dug	1,546	34	24	24	RM	Hard	Stk.	Also a well at house
25	NE	Brd.	1,522	31	19	-	RM	Hard	Dom. Stk.	Sufficient supply
27	NE	Dug	1,531	16	12	-	Gravel	Hard	Dom. Stk.	Sufficient for 20 head
28	NE	Dug	1,480	8	6	-	RM	Hard	Dom. Stk.	Spring in the bedrock
29	SW	Dug	1,495	22	19	8	RM	Hard	Dom.	Also a well 28 feet deep
30	SE	Dug	1,415	14	12	-	-	Hard	Dom. Stk.	Two wells
31	SE	Dug	1,399	20	12	-	-	Hard	Dom.	Sufficient supply
32	SW	Dug	1,403	37	7	37	RM	Hard	Dom. Stk.	Sufficient supply
34	SW	Dug	1,499	18	12	-	-	Hard	Dom.	Sufficient supply
35	NW	Dug	1,548	21	14	-	-	Hard	Dom.	Sufficient supply
36	NE	Dug	1,530	24	14	-	RM	Hard	Stk.	Also a house well 24 feet deep

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 6, Range 11

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Brd.	1,571	65	30	-	RM	Hard	Dom. Stk.	Sufficient supply
2	SE	Dug	1,500	20	17	-	Sand	Hard	Dom. Stk.	
3	NW	Dug	1,453	22	12	18	RM	Hard	Dom. Stk.	Sufficient supply
4	SW	Dug	1,459	20	17	-	Gravel	Hard	Dom. Stk.	Also a well dug 45 feet
5	NW	Dug	1,466	35	31	-	RM	Hard	Dom. Stk.	
6	SW	Dug	1,451	20	10	-	RM	Hard	Dom. Stk.	Sufficient supply
8	NW	Dug	1,485	17	13	-	Till	Hard	Dom. Stk.	Sufficient supply
9	NE	Dug	1,463	13	8	-	-	Hard	Dom. Stk.	Sufficient supply
10	NW	Dug	1,495	30	24	-	-	Hard	Stk.	Also a domestic well
11	SE	Brd.	1,490	54	35	-	RM	Hard	Dom. Stk.	Not sufficient for 18 head
12	SE	Dug	1,588	30	20	-	RM	Hard	Dom. Stk.	Sufficient supply
13	SW	Drl.	1,565	86	40	-	RM	Hard	Stk.	Also a house well 30 feet deep
14	NE	Brd.	1,604	74	24	-	RM	Hard	Stk.	Also a house well 33 feet deep
15	SE	Dug	1,477	24	20	-	-	Hard	Dom. Stk.	Has been dry in summer months
16	SW	Dug	1,465	17	13	-	Gravel	Hard	Dom. Stk.	Sufficient for 15 head
17	NE	Drl.	1,466	75	20	20	RM	Hard	Dom.	Well at Convent in Bruxelles
18	NW	Dug	1,413	28	18	-	Sand	Hard	Dom. Stk.	Sufficient for 40 head
20	SW	Dug	1,418	26	20	25	RM	Hard	Dom. Stk.	Two other dug wells
21	SE	Dug	1,437	14	8	-	Gravel	Hard	Dom. Stk.	Sufficient for 20 head
22	NE	Dug	1,607	32	13	-	Gravel	Hard	Dom. Stk.	Sufficient supply
23	NE	Dug	1,557	24	16	-	RM	Hard	Dom.	Sufficient supply
24	NE	Dug	1,450	42	25	-	RM	Hard	Dom. Stk.	Sufficient supply
26	SW	Dug	1,599	22	14	-	RM	Hard	Dom. Stk.	Dug a dry hole 40 feet deep
28	SW	Dug	1,403	27	21	-	Drift	Hard	Stk.	Sufficient for 10 head
29	SE	Dug	1,419	70	16	-	RM	Hard	Dom. Stk.	Sufficient for 30 head
30	NE	Dug	1,386	15	11	-	Sand	Hard	Dom. Stk.	Sufficient supply
32	NE	Dug	1,353	17	12	-	Drift	Hard	Dom. Stk.	Sufficient for 15 head
34	NW	Dug	1,404	25	13	-	RM	Hard	Dom. Stk.	Sufficient for 14 head
35	NW	Dug	1,391	20	-	-	RM	Hard	Dom. Stk.	Also a well 107 feet
36	SW	Dug	1,388	33	24	-	-	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA

Township 6 Range 12

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Dug	1,440	15	9	15	RM	Hard	Dom. Stk.	Sufficient supply
4	SW	Dug	1,323	25	17	-	Drift	Hard	Dom. Stk.	Sufficient supply
6	SW	Dug	1,465	27	16	-	-	Hard	Dom. Stk.	Also a well bored 80 feet
7	NW	Dug	1,290	23	13	-	-	Hard	Dom. Stk.	Sufficient supply
8	NW	Drl.	1,296	107	36	-	RM	Hard	Dom. Stk.	Alkali Water
9	NW	Dug	1,365	28	25	28	-	Hard	Dom.	Water at contact of gravel and shale
10	SW	Dug	1,420	15	5	14	RM	Hard	Dom. Stk.	Sufficient supply
11	SW	Brd.	1,421	33	15	-	Drift	Hard	Dom. Stk.	Alkali water
11	SE	Dug	1,453	60	58	-	RM	Hard	Dom. Stk.	Dry in summer months
12	SE	Dug	1,475	35	18	15	RM	Hard	Dom. Stk.	Sufficient for 20 head
13	SE	Dug	1,434	24	7	-	-	Hard	Dom. Stk.	Sufficient supply
15	SE	Dug	1,398	33	23	10	RM	Hard	Dom.	Also a well 20 feet deep in gravel
16	NW	Dug	1,327	30	26	-	Drift	Hard	Dom. Stk.	Sufficient supply
17	NE	Dug	1,369	40	15	-	RM	Hard	Dom. Stk.	Sufficient supply
18	NE	Dug	1,244	14	10	-	Sand	Hard	Dom. Stk.	Sufficient supply
19	SW	Dug	1,242	12	8	-	Sand	Hard	Dom. Stk.	Sufficient supply
20	SW	Brd.	1,264	42	23	-	Drift	Hard	Dom.	Stock well drilled 90 feet deep
22	SE	Dug	1,392	28	14	-	Sand	Hard	Dom. Stk.	Sufficient for 25 head
24	SW	Dug	1,399	17	13	-	Sand	Hard	Dom. Stk.	Sufficient for 16 head
25	NW	Brd.	1,413	70	40	13	RM	Hard	Dom. Stk.	Three other wells (each) 70 feet deep
26	NW	Brd.	1,361	42	33	-	-	Hard	Dom. Stk.	Two other wells 30 and 47 feet deep
27	NW	Dug	1,327	20	18	-	RM	Hard	Dom. Stk.	Sufficient supply
28	SW	Dug	1,309	43	23	-	RM	Hard	Dom.	Sufficient supply
30	NE	Dug	1,257	15	4	-	-	Hard	Dom.	Stock well 46 feet deep
31	NW	Dug	1,238	32	13	-	-	Hard	Stk.	Sufficient for 100 head
32	NW	Dug	1,254	22	12	6	RM	Hard	-	Well dug 1951
33	SW	Dug	1,305	28	11	-	-	Hard	Dom. Stk.	Sufficient supply
34	NW	Dug	1,293	30	18	-	-	Hard	Dom.	Sufficient supply
35	NE	Dug	1,354	40	32	10	RM	Hard	Dom.	Stock well 12 feet deep
36	SW	Dug	1,367	27	15	-	Gravel	Hard	Dom. Stk.	Sufficient supply

REPRESENTATIVE WELL RECORDS, PILOT MOUND AREA, MANITOBA
Township 6, Range 13

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Depth to bedrock (feet)	Aquifer	Quality of Water	Use	Remarks
1	NW	Dug	1,371	38	34	20	RM	Hard	Dom. Stk.	Sufficient for 20 head only
2	NW	Dug	1,314	35	31	-	-	Hard	Dom. Stk.	Too hard for laundry
7	SE	Brd.	1,309	44	9	-	-	Hard	Stk.	
8	SW	Dug	1,312	20	-	-	Sand	Hard	Dom. Stk.	Two wells on farm
9	NW	Dug	1,327	32	-	-	RM	Hard	Stk.	Sufficient for 60 head
10	SW	Dug	1,326	40	33	20	RM	Hard	Dom. Stk.	Sufficient supply
12	SW	Dug	1,338	58	15	-	RM	Hard	Dom. Stk.	Sufficient supply
13	SE	Drl.	1,302	100	46	-	RM	Hard	Dom. Stk.	Have a dugout
14	NE	Dug	1,248	12	9	-	Sand	Hard	Dom. Stk.	Sufficient supply
14	SW	Dug	1,280	30	15	13	RM	Hard	Dom. Stk.	Sufficient supply
15	SE	Drl.	1,274	80	-	30	RM	Hard	Stk.	House well 21 feet deep
16	SE	Dug	1,270	14	5	-	Sand	Hard	Stk.	Also a house well
17	SE	Dug	1,264	19	5	-	Gravel	Hard	Stk.	House well 10 feet deep
18	SW	Brd.	1,319	61	22	-	RM	Hard	Dom. Stk.	Sufficient supply
19	SW	Brd.	1,253	90	15	-	RM	Hard	Stk.	Not sufficient in dry years
20	NW	Dug	1,248	23	16	-	Sand	Hard	Stk.	Also a sandpoint 30 feet deep
22	SW	Dug	1,259	32	26	-	Sand	Hard	Stk.	Also a sandpoint 32 feet deep
24	NE	Dug	1,235	12	9	-	Sand	Hard	Dom. Stk.	Sufficient for 100 head
25	NW	Dug	1,248	22	12	-	Drift	Hard	Dom. Stk.	Alkali water
26	SW	Brd.	1,233	35	20	-	Sand	Hard	Dom. Stk.	Sufficient supply
27	SW	Brd.	1,230	28	8	-	-	Hard	Dom. Stk.	Stock well 22 feet deep
28	NE	Dug	1,232	17	11	-	Drift	Hard	Not	Temperature of water 42°F.
30	SE	Dug	1,240	30	27	-	Gravel	Hard	Dom. Stk.	Sufficient supply
31	NW	Drn.	1,247	30	-	-	Sand	Hard	Dom. Stk.	Two sandpoints 18 and 20 feet deep
34	NE	Dug	1,234	16	8	-	Sand	Hard	Dom. Stk.	Sufficient supply
35	NW	Dug	1,234	20	15	-	Sand	Hard	Dom. Stk.	Also a well 18 feet deep
36	SW	Dug	1,244	22	21	-	Till	Hard	Dom. Stk.	Also a well 19 feet deep

CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 326

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(Brandon-Souris Area)

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PART I

INTRODUCTION

The present report is an attempt to assemble the data on ground-water resources in a form that will be useful to well drillers, farmers, municipal authorities, and others interested in obtaining adequate water supplies.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports that, in Manitoba, cover a square block of sixteen townships lying between the correction lines and beginning at the Saskatchewan boundary. The reports on the most southerly strip of the province include in addition the two townships lying north of the International Boundary. The secretary-treasurer of each municipality will be supplied with the information covering that municipality, and copies of the reports will also be available for study at offices of the Provincial and Federal Departments. Further assistance in interpreting the reports may be obtained by applying to the Chief Geologist, Geological Survey of Canada, Ottawa.

How to Use the Report

Anyone desiring information concerning ground-water in any particular locality will find the available data listed in the well records, and other pertinent information on the maps of the area. For those unfamiliar with these reports it is, perhaps, advisable that that part dealing with the area as a whole be read first, so as to be in a better position to understand the more particular descriptions of each township that follow. Also, the map accompanying the report should prove a useful source of reference when reading the text.

The map consists of two figures. Figure I shows bedrock and surface geology. The water-bearing properties of the bedrock change from formation to formation, and are referred to in subsequent pages. The type of glacial deposit at the surface may be determined from the map, and its possibilities as an aquifer are also discussed in this report.

Figure 2 shows the location and types of wells in the area, the land relief (topography), and the drainage pattern. Not every well is plotted on the map, but most of those giving pertinent information are shown, and probably include 90 per cent of the wells in the area. Where ground water is not readily available, or carries too much dissolved salts to be used, dugouts often form the only means of supply. The topography is shown by contours, or lines of equal elevation, spaced at vertical intervals of 50 feet.

The well records are compiled from data obtained by interviewing farmers, and in many cases their accuracy depends upon the farmer's memory. Wherever possible data were checked by plumb-line measurement to the nearest foot. The wells are tabulated by townships and sections, and the total depth of the well, depths to the water level at high and low stages, and, where possible, the depth at which the water-bearing horizon occurs, are all listed. The general character of the water is stated, and the use to which it can be put. Wells from which samples were taken for analysis are indicated on the well-record sheets. An idea of how much water a well can be expected to yield is suggested by the number of stock (cattle and horses only) that can be watered at it. One head is assumed to consume between 8 and 10 ~~gallons of~~ water a day. Unless ~~followed by the word "only"~~

the figure for the number of stock watered is not necessarily the maximum yield of the well, but simply the greatest amount that the present user has required. The word "only" indicates that the figure given is the maximum yield of the well. To obtain the position of an aquifer at any given point, the elevation of the point should be determined from the contours on Figure 2 of the map. Elevations of adjacent wells may be found in the well records and the depth to the aquifer can usually be determined from them. By comparing elevations the depth of the aquifer below the unknown point may be estimated. This method is particularly applicable to bedrock wells, but may not be successful where information is too limited, or where the glacial drift is thick and of an irregular character. In such instances a person searching for water should refer to the text for information on the nature of the deposits in that area.

GLOSSARY OF TERMS USED

Alkaline. The term 'alkaline' or 'alkali' water has been applied rather loosely to waters having a peculiar and disagreeable taste, and commonly a laxative effect. The waters so described in the Prairie Provinces are those heavily charged with sulphates of magnesium and sodium (respectively Epsom salts and Glauber's salts) and are more correctly termed sulphate waters. Truly 'alkaline' waters owe that property to the presence of calcium carbonate and calcium bicarbonate. In this report an attempt to adhere to local terminology is made by referring to sulphate waters as 'alkali' in the well records, and the term 'alkaline' is avoided.

Alluvium. Deposits of clay, silt, sand, gravel, and other material in lake beds and in flood plains of modern streams. The term also includes the material in river terraces, which once formed part of the flood plain but are now above it.

Aquifer. A porous bed, lens, pocket, or deposit of material that transmits water in sufficient quantity to satisfy pumping wells and springs.

Bedrock. Bedrock, as here used, refers to partly or wholly consolidated deposits of gravel, sand, silt, clay, and marl that are older than the glacial drift.

Bentonite and bentonitic clays have the property of swelling when water is added to them. They occur as white beds as much as 2 feet thick, but usually much thinner, and are probably formed by the weathering of volcanic ash.

Buried pre-Glacial Stream Channel. A channel eroded into the surface of the bedrock by a stream before the advance of the continental ice-sheet, and subsequently either partly or wholly filled in by sands, gravels, and boulder clay deposited by the ice-sheet or later agencies.

Coal Seam. The same as a coal bed. It is a deposit of carbonaceous material formed from the remains of plants by partial decomposition and burial.

Contour. A line on a map joining points that have the same elevation above sea-level.

Continental Ice-sheet. The great ice-sheet that covered most of the surface of Canada many thousands of years ago.

Escarpment. A cliff or relatively steep slope separating level or gently slopping areas.

Flood Plain. A flat part of a river valley ordinarily above water but submerged when the river is in flood. It is an area where silt and clay are being deposited.

Glacial Drift. A general term that includes all the loose, unconsolidated materials that were deposited by the ice-sheet, or by the waters associated with it. Clay containing boulders usually forms a large part of the glacial drift in an area, and is called glacial till or boulder clay, and is not to be confused with the more general term glacial drift, which occurs in the following several forms:

(1) Terminal Moraine or Moraine. A ridge or series of ridges formed by glacial drift that was laid down at the margin of a moving ice-sheet. The surface is characterized by irregular hills and undrained basins.

(2) Kame Moraine. Assorted deposits of sand and gravel laid down at or close to the ice margin. The topography is similar to that of a terminal moraine.

(3) Ground Moraine. Boulder clay (till) laid down at the base of an ice-sheet. The topography may vary from flat to gently rolling.

(4) Glacial Outwash. Sand and gravel plains or deltas formed by streams that issued from the continental ice-sheet.

(5) Glacial-lake Deposits. Sand, silt, and clay deposited in glacial lakes during the retreat of the ice-sheet.

Shoreline. A discontinuous escarpment, with intervening gravel beaches and bars, which indicates the former margin of a glacial lake.

Ground Water. The water in the zone of saturation below the water-table.

Hydrostatic Pressure. The pressure that causes water in a well to rise above the point at which it was first encountered in the well, namely, at the level of the aquifer.

Impervious or impermeable. Beds such as fine clays or shale are considered to be impermeable when they do not permit the perceptible passage or movement of ground water.

Pervious or Permeable. Beds are pervious or permeable when they permit the perceptible passage or movement of ground water, as in the case of sands and gravels.

Pre-Glacial Land Surface. The surface of the land as it existed before the ice-sheet covered it with drift.

Recent Deposits. Deposits that have been laid down by the agencies of water and wind since the disappearance of the continental ice-sheet; for example, alluvium in stream valleys.

Sand Point or Driven Well. A sand point is a piece of perforated and screened pipe 2 or 3 feet long, which ends in a sharp point. It is fastened to lengths of ordinary pipe and forced down into surface deposits of a sandy or gravelly nature. The depth of such a well rarely exceeds 30 feet.

Unconsolidated Deposits. The mantle or covering of alluvium, pre-glacial soils, and glacial drift consisting of loose, uncemented material that overlies the bedrock.

Variegated. Beds so described show different colours in alternating beds or lenses.

Water-table. The upper limit of the part of the ground saturated with water. This may be near the surface or many feet below it. A water-table is said to be perched when a zone of saturated material is separated from the main water-table below by a zone or zones of unsaturated material.

Water-worked Till. Glacial till or boulder clay that has been subjected to water action, usually near the margins of glacial lakes, so that the fine clay has been washed out and a deposit that may be composed mainly of sand and gravel is left behind.

Wells. The term refers to any hole sunk in the ground by any means for the purpose of obtaining water. If no water is obtained they are referred to as dry holes. Wells yielding water are divided into four classes:

(1) Flowing Artesian Wells. Wells in which the water is under sufficient hydrostatic pressure to flow above the surface of the ground at the well.

(2) Non-flowing Artesian (Sub-artesian) Wells. Wells in which the water is under sufficient hydrostatic pressure to raise it above the level of the aquifer, but not above the level of the ground at the well.

(3) Non-artesian Wells. Wells in which the water does not rise above the water-table or the aquifer.

(4) Intermittent Non-artesian Wells. Wells that are generally dry for a part of each year.

GENERAL DISCUSSION OF GROUND WATER

Almost all the water recovered from beneath the earth's surface for both domestic and industrial uses is meteoric water, that is, water derived from the atmosphere. Most of this water reaches the surface as rain or snow. Part of it is carried off by streams as run-off; part evaporates either directly from the surface and from the upper mantle of soil, or indirectly through transpiration of plants; and the remainder sinks into the ground to be added to the ground-water supplies.

The proportion of the total precipitation that sinks into the ground will depend largely upon the type of soil or surface rock, and on the topography; more water will sink into sand and gravel, for example, than into clay; if, on the other hand, the region is hilly and dissected by numerous streams, more water will be immediately drained from the surface than in a relatively flat area. Light, continued precipitation will furnish more water to the underground supply than brief torrential floods, during which the run-off may be nearly equal to the precipitation. Moisture failing on frozen ground will not usually find its way below the surface, and, therefore, will not materially replenish the ground-water supplies. Light rains falling during the growing season may be wholly absorbed by plants. The quantity of moisture lost through direct evaporation depends largely upon temperature, wind, and humidity. Locally these deposits may become very extensive. The water-bearing properties of alluvial deposits are variable, but, in general, such deposits form favourable aquifers. They are porous, and readily yield a part of their contained water, although in places their porosity may be greatly reduced by the presence of fine silt and clay. This type of deposit may be expected to yield moderate domestic supplies through shallow wells, and larger supplies if the deposits are extensive.

In some areas of relatively steep slopes, valleys have been partly filled with sand and gravel, which, in turn, have been covered with impervious clay and silt. These circumstances commonly give rise to artesian conditions in the lower part of the valley.

DISCUSSION OF WATER ANALYSES

Both the kind and quantity of mineral matter dissolved in a natural water depend upon the texture and chemical composition of the rocks with which the water has been in contact. Pollution is caused by contact with organic matter or its decomposition products. Analyses of well waters for mineral content are made by the Department of Health and Public Welfare, Winnipeg, and by the Bureau of Mines, Department of Mines and Resources, Ottawa.

As the ground-water survey of Manitoba progresses an effort is made to secure samples representative of each major aquifer encountered; the purpose of this is to compare the chemical characteristics of waters from the various geological horizons and, thereby, assist in making correlations of the strata in which the waters occur. The mineral content of natural waters is also of interest to the consumers, though the effects of the constituents are usually already apparent. The quantities of the various constituents for which tests are made are given as 'parts per million', which refers to the proportion by weight of each constituent in 1,000,000 parts of water. A salt when dissolved in water separates into two chemical units called 'radicals', and these are expressed as such in the chemical analyses. In one group are included the metallic elements of calcium (Ca), magnesium (Mg), sodium (Na), and iron (Fe), and in the other group are the sulphate (SO_4), chloride (Cl), bicarbonate (HCO_3), carbonate (CO_3), and nitrate (NO_3) radicals. The radicals listed in the analyses tabulated in the second part of this report can be combined to give the actual quantity of the particular salts present in the water, but this is not done here as the radicals alone give enough information to identify the water types. In fact, the sulphate, chloride, and carbonate radicals, plus the hardness, serve to identify a water, and crude field tests on the basis of these constituents were used in some areas to outline more completely zones of the various water types.

The following mineral constituents include all that are commonly found in natural waters in quantities sufficient to have any practical effect on the value of waters for ordinary uses:

Silica (SiO_2) is dissolved in small quantities from almost all rocks. It is not objectionable except in so far as it contributes to the formation of boiler scale.

Iron (Fe) in combination is dissolved from many rocks as well as from iron sulphide deposits with which the water comes in contact. It may also be dissolved from well casings, water pipes, and other fixtures in quantities large enough to be objectionable, but separates as the hydrated oxide upon exposure of the water to the atmosphere. Excessive iron in water causes straining on porcelain or enamelled ware, and renders the water unsuitable for laundry purposes. Water is usually considered not potable if the iron content is more than 0.5 part per million.

Calcium (Ca) in the water comes from mineral particles present in the surface deposits, the chief sources being limestone, gypsum, and dolomite. Fossil shells provide a source of calcium, as does also the decomposition of igneous rocks. The common compounds of calcium are calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$), neither of which have injurious effects on the consumer, but both of which cause hardness.

Magnesium(Mg) is a common constituent of many igneous rocks therefore, very prevalent in ground water. Dolomite, a carbonate calcium and magnesium, is also a source of the element. The sul-

magnesia ($MgSO_4$) combines with water to form 'Epsom salts,' and renders the water unwholesome if present in large amounts.

Sodium(Na) is derived from a number of the important rock-forming minerals, so that sodium sulphate and carbonate are very common in ground waters. Sodium sulphate (Na_2SO_4) combines with water to form 'Glauber's salt' and excessive amounts make the water unsuitable for drinking purposes. Sodium carbonate (Na_2CO_3) or 'black alkali' waters are mostly soft, the degree of softness depending upon the ratio of sodium carbonate to the calcium and magnesium salts. Waters containing sodium carbonate in excess of 200 parts per million are unsuitable for irrigation purposes[1]. Sodium sulphate is less harmful.

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[1]"The extreme limit of salts for irrigation is taken to be 70 parts per 100,000, but plants will not tolerate more than 10 to 20 parts per 100,000 of black alkali (alkaline carbonates and bicarbonates)". Frank Dixey, in 'A Practical Handbook of Water Supply', Thos. Murby & Co., 1931, p. 254.

Sulphates (SO_4) referred to in this report are those of calcium, magnesium, and sodium, and have been mentioned above in referring to these radicals. They are also formed by oxidation of iron sulphides, and, hence, it is not uncommon to find iron in sulphate waters. Sulphates cause permanent hardness in water, and injurious boiler scale. Sodium and magnesium sulphates are laxative when present in quantities of more than 900 parts per million. The writers found that acclimatized people could drink water containing as much as 2,000 parts per million of all three of the principal sulphates, but that when all were present in quantities over 1,500 parts per million the water was commonly laxative to those not accustomed to it.

Chloride (Cl) is a constituent of all natural waters and is dissolved in small quantities from rocks. Waters from wells that penetrate brines or salt deposits contain large quantities of chloride, usually as sodium chloride (common salt) and less commonly as calcium chloride and magnesium chloride. Sodium chloride is a characteristic constituent of sewage, and any locally abnormal quantity suggests pollution from this source. However, such abnormal quantities should not, in themselves, be taken as positive proof of pollution in view of the many sources from which chloride may be derived. Chlorides impart a salty taste to water if present much in excess of 500 parts per million. In southwestern Manitoba waters with as much as 3,000 parts per million of chloride are used domestically, though more than 1,500 parts per million is generally considered undesirable. The following figures apply to chlorides: stock will require less salt if the water bears 2,000 parts per million; more than 5,000 parts per million is unfit for human consumption; more than 8,000 parts per million is unfit for horses; more than 9,500 parts per million is too much for cattle; and more than 15,500 parts per million is excessive for sheep. Magnesium chloride, less common than sodium chloride, is very corrosive to metal plumbing.

Nitrates(NO_3) found in ground water are decomposition products of organic materials; they are not harmful in themselves, but they do point to probable pollution. It is recommended that a bacterial test be made on water showing an appreciable nitrate content, if it is to be used for domestic purposes.

Carbonates (CO_3) in water are indicated in the table of analyses as 'alkalinity'. Calcium and magnesium carbonate cause hardness in water, which may be partly removed by boiling. Sodium carbonate causes softness in waters, and is referred to under 'Sodium' above.

Bicarbonates (HCO_3). Carbon dioxide dissolved in water renders the insoluble calcium and magnesium carbonates soluble as bicarbonates. The latter are decomposed by boiling the water, which changes them to insoluble carbonates.

Hardness is a condition imparted to waters chiefly by dissolved calcium and magnesium compounds. It here refers to the soap-destroying power of water, that is, to the amount of soap that must first be used to precipitate the above compounds before a lather is produced. The hardness of water in its original state is its total hardness, and is classified as 'permanent hardness' and 'temporary hardness'. Permanent hardness remains after the water has been boiled. It is caused by mineral salts that cannot be removed from solution by boiling, but it can be reduced by treating the water with natural softeners, such as ammonia or sodium carbonate, or with many manufactured softeners. Temporary hardness can be eliminated by boiling, and is due to the presence of bicarbonates of calcium and magnesium. Waters containing large quantities of sodium carbonate and small amounts of calcium and magnesium compounds are soft, but if the latter compounds are present in large quantities the water is hard. The following table[1] may

[1]Thresh, J.C., and Beale, J.F.: The Examination of Waters and Water Supplies; London, 1925, p. 21.

be used to indicate the degree of hardness of a water:

Total Hardness

Parts per million	Character
0-50	Very soft
50-100	Moderately soft
100-150	Slightly hard
150-200	Moderately hard
200-300	Hard
300 +	Very hard

The above table gives the generally accepted figures for hardness, but the people of southwestern Manitoba have become accustomed to harder waters, and the following table, based on about 800 field determinations of hardness, by the soap method, is more applicable:

Parts per million	Character
0-100	Very soft
100-150	Soft
150-250	Moderately hard
250-350	Hard
350-500	Very hard
500+	Excessively hard

Waters having a hardness of up to 300 parts per million are commonly used for laundry purposes. In southwestern Manitoba, h[illegible] ranges from less than 50 parts per million to more than [illegible] r million.

PART II

TOWNSHIPS 7 TO 10, RANGES 18 TO 21, WEST PRINCIPAL MERIDIAN, MANITOBA (Brandon-Souris Area)

Introduction

An investigation of the glacial geology and ground-water resources of the Brandon-Souris area was conducted by the writer during the field season of 1949. J. A. Elson completed the mapping of the glacial deposits in 1953 and has supplied a part of figure 1 and that part of this report describing the glacial geology.

Physical Features

The end moraine deposits covering much of the southeast quarter of the area have an irregular surface marked by knolls, hummocks, and depressions occupied by ponds and small lakes such as Lake Clementi. The northern part of this moraine forms Brandon Hills about 9 miles south of Brandon; these have elevations of nearly 1,600 feet, or 400 feet above the level of Assiniboine River at Brandon. Elsewhere the area is covered by glacial lake deposits forming a nearly level plain.

Assiniboine River follows a flat-bottomed valley that crosses township 10 and is in places more than a mile wide and as much as 150 feet deep. East of Brandon the Assiniboine Valley becomes broader and has low banks where it cuts delta and fan deposits. Souris River crosses the southwest part of the area in a valley less than half a mile wide and about 80 feet deep.

Geology

Table of Formations

Age	Formation	Character	Thickness (feet)
Recent	Alluvium	Stream-laid mud, silt, sand, and gravel	
Pleistocene	Lake beds	Silt, sand, clay, duned sand; sand and gravel as alluvial fans and deltas	0-50
	Glacial drift	Till, clay, boulders, sand and gravel as outwash plains	0-200
Tertiary	Gravel	Quartzite pebble gravel and sand (locally cemented)	
Upper Cretaceous	Riding Mountain	Upper beds of medium to light grey, hard, siliceous shale (Odanah shale), with some thin layers of fine, blue sand and bentonite; lower beds of clay shale that tends to slump	1,000 ±

Upper Cretaceous shale of the Riding Mountain formation underlies the area and outcrops along the valley of Souris River. The fissured and weathered surface layers of the bedrock are water-bearing in most parts of the Brandon-Souris area. The Riding Mountain formation is underlain by the Vermilion River formation with a total thickness of about 410 feet[1]. The shales are overlain by 75 to 100 feet of overburden.

[1]Wickenden, R.T.D.: Mesozoic Stratigraphy of the Eastern Plains, Manitoba and Saskatchewan; Geol. Surv., Canada, Mem. 239, 1945.

East of the town of Souris, in NW. 1/4 sec. 35, tp. 7, rge. 21, a gravel pit exposes a thickness of at least 20 feet of well-rounded quartzite-pebble gravel, sand, sandstone, and conglomerate. The gravel contains pebbles of lignite and silicified wood (agate). This deposit is evidently

Tertiary in age and probably correlates either with the Boissevain sandstone that outcrops on Turtle Mountain 30 miles south, or with the somewhat younger quartzite gravels in the Wood Mountain district of southern Saskatchewan.

South of Souris, in NE. 1/4 secs. 33 and 34, tp. 7, rge. 21, pits expose gravel in the valley of Souris River. This is mainly comprised of quartzite pebbles, but there are some other stones, and the sand matrix, where present, is unlike that of the bedrock described in the preceding paragraph. This gravel is reworked Tertiary gravel with a slight amount of glacial material added, and apparently is a linear body trending east from NE. sec. 33, where it is overlain by 20 feet of silt and sand. This gravel is probably a good prospect for potable ground water.

The surface deposits of the Brandon-Souris area are the products of two glacier lobes. One of these retreated to the northwest while a glacial lake formed in front of it. In the meantime an ice lobe from the east advanced westward, overrode some of the lake sediments and deposited some ground moraine and formed a small end moraine. The eastern ice withdrew by a process of shrinking northward and a second glacial lake was formed between it and the end moraine. This lake was drained as Lake Agassiz came into existence. Later Assiniboine River flowed east across the northern part of the map-area and deposited large quantities of sand and gravel as a delta in glacial Lake Agassiz.

The main mass of end moraine is the interlobate moraine in tps. 7 to 9, rges. 18 and 19, and includes the Brandon Hills. In areas of this end moraine the local relief is 10 to 75 feet and the material is mainly a sandy till with small bodies of sand and gravel. The drift is probably over 100 feet thick in this end moraine. A mass of ice-contact stratified drift shown in the central part of tp. 8, rge. 19, is partly outwash. An end

moraine that averages only 1 mile or less in width extends across rges. 18 to 21, tp. 8, into tp. 9, rge. 20. In rges. 20 and 21 this moraine is interrupted by belts of ground moraine and areas of water-worked drift (a lag concentrate of silt, sand, and pebbles, from 1 foot to 3 feet thick, that overlies till and is grouped with lake deposits on the map). The moraine is composed of sandy, silty till and has about 10 feet of local relief. The end moraines extending from sec. 26, tp. 9, rge. 19, to sec. 20, tp. 9, rge. 18, and from sec. 31, tp. 9, rge. 18, into sec. 21, tp. 9, rge. 18, are deposits of silt with a rolling surface having 10 to 15 feet of relief. These deposits are arbitrarily mapped as end moraine because they appear to represent deposits of ice margins that caused glacial spillways to trend along the slope instead of down it. Another body of end moraine, composed of till, begins north of Alexander and extends to within a mile of Kenmay. The till is sandy and it overlies earlier lake sediments. The relief in this end moraine is from 10 to 30 feet.

Ground moraine composed of sandy, silty till is mapped in tp. 7, rge. 18, with smaller areas in tp. 8, rges. 20 and 21. A similar deposit, but more silty in character, occurs in tps. 10 and 9, rge. 21, south of Alexander. The topography generally has less than 5 feet of relief and consists of a large number of shallow closed depressions in a nearly level plain. North of Alexander, in tp. 10, rge. 21, the ground moraine is a silt that was deposited in a glacial lake and reworked by overriding ice. This silty till that overlies lake silt within a few feet of the surface contains few pebbles.

The lake deposits were not subdivided in mapping. They include silt, sand, water-worked drift, and clay, in that order of abundance. The lake deposits in the southwest part of the area are oldest and are described first.

Most of the lake deposits in tp. 7, rges. 19 to 21, are silt. Near Carroll this is at least 20 feet thick. Along Souris River in rge. 20 water-worked drift predominates. Sand occurs in the northwest corner of tp. 7, rge. 21, and in the part of tp. 8, rge. 21, southwest of a line joining secs. 2 and 30. Northeast of this line silt is exposed except in a triangular area of about 12 square miles in tps. 8 and 9, rge. 23, where clay is present. The surface of this area has about 5 feet of relief and there are many closed depressions. The clay probably is thin and overlies ground moraine. East of Souris water-worked drift (1 foot to 2 feet of residual silt, sand, and stones) overlying till borders the end moraine.

Lake deposits in the north and east part of the area are predominantly silt with some irregular areas of medium-grained sand. Sand extends from the ground moraine south of Alexander east to a little beyond Kenmay and south beyond the channel that crosses tp. 9, rge. 20, from west to east; this sand area also extends east through the south part of tp. 9, rges. 20 and 19. An area of lake sand about 2 square miles in extent lies southwest of Brandon. The remainder of the lake deposits are silt, which varies in thickness from 3 feet to at least 20 feet.

The problem of distinguishing deltas from alluvial fans in the Brandon area is very difficult because neither foreset nor bottomset beds are visible. Consequently, the term delta-fan is applied in this discussion. Above the 1,250-foot contour the delta-fan deposits are of fine gravel and sand up to about 20 feet thick. One interesting belt of sand and gravel extends from sec. 8, tp. 10, rge. 19, to sec. 30, tp. 9, rge. 18. This is alluvium deposited in a channel in existence at an early stage of Assiniboine and Minnedosa Rivers; the silt that formed the south wall of the channel later was eroded.

Below the 1,250-foot contour, in tps. 9 and 10, rge. 18, are delta deposits formed where Assiniboine River flowed into glacial Lake Agassiz. They may be as much as 40 feet thick and they consist of coarse sand and medium to fine pebble gravel. Included in this map-unit are several areas of water-worked drift, in the vicinity of secs. 2, 9, 10, 14, 23, and 25, tp. 10, rge. 18, and secs. 24, 25, 26, 27, 34, 35, and 36, tp. 9, rge. 18.

The sediment in the channel extending east from Alexander is sand; locally this channel is not marked by walls but is represented merely by a low swampy belt through an area of undulating wind-blown sand. Near Brandon and Kenmay the channel deposits are in steep-walled former water-courses and range from sand to coarse pebble gravel. These deposits are typically poorly sorted and less than 4 feet thick.

Water Supply

There is a sufficient supply of water for domestic use but on many farms, to assure a supply for stock, dugouts are required for the storage of run-off and spring-melt water. Delta and alluvial fan deposits south and east of Brandon are excellent aquifers favourably situated to receive maximum replenishment from rainfall and snow-melt. Other suitable locations for wells and also a probable source of supply during seasons of less than normal rainfall are the lenses of sand and gravel along intermittent and abandoned channels. Ground and end moraine, present largely as silty tills, are not appreciably permeable and producing wells in them usually obtain their water from discontinuous lenses of sand or gravel in the till. These supplies may fail in successive seasons of less than normal rainfall. A supply of potable water may be available at the contact of the overburden and bedrock or in the uppermost fractured zones of the bedrock itself. Aquifers in the bedrock, however, usually yield salty water suitable only for stock, but some yield potable soft water.

The city of Brandon requires 2,300,000 gallons of water a day. This supply is taken from Assiniboine River at Brandon and subjected to filtration, softening, and chlorination processes before it is stored in reservoirs ready for distribution.

The town of Souris has a daily consumption of 50,000 gallons, which are taken from Souris River at Souris, purified, and stored in reservoirs and pressure tanks before distribution.

Township 7, Range 18. Ground moraine covers most of the township. The surface is rolling and uneven even though it has been modified by the waters of glacial Lake Souris. Two intermittent creeks flow eastward across the northern half of the township and Souris River crosses section 1.

Wells dug 25 to 30 feet deep into lenses of gravel or sand within the ground moraine furnish adequate supplies of water, especially in seasons of abundant rainfall. In drier years such wells may yield less than 10 gallons of water a day; hence dugouts are common throughout the township.

The possibility of a water supply from the bedrock is not known. Wells, penetrating unconsolidated deposits, were drilled 160 and 150 feet in NW. 1/4 sec. 2 and SE. 1/4 sec. 5, respectively, and yield salty water, as does a well 200 feet deep in SW. 1/4 sec. 16. Dry test holes 130 and 135 feet deep were drilled in NW. 1/4 sec. 22 and SW. 1/4 sec. 27, respectively.

The village of Nesbitt, in sec. 28, has four wells dug 30 to 40 feet into ground moraine. These wells are almost full in spring and in dry seasons contain on the average 2 to 3 feet of water.

Township 7, Range 19. The uneven surface of this township rises to elevations of more than 1,500 feet in the area of end moraine. This high area slopes to the valley of Souris River in section 6 where the elevation is less than 1,350 feet.

Discontinuous lenses of sand or gravel within end or ground moraine supply sufficient water for 75 to 100 head of stock. Wells 15 to 45 feet deep reach these aquifers but in secs. 5, 8, 17, and 18 a supply of water is available from springs.

The first well in this township was drilled in 1889 on SE. 1/4 sec. 24 and during the years 1911 - 14 a number of wells were drilled. Of these, dry holes were reported on secs. 9 and 12, drilled 205 and 270 feet deep, respectively. Water-bearing gravel was encountered at depths of 130 and 256 feet in wells drilled in NW. 1/4 sec. 17 and NW. 1/4 sec. 30, respectively. Aquifers yielding salty water were encountered within the bedrock in wells drilled 181 and 145 feet deep in NW. 1/4 sec. 12 and SW. 1/4 sec. 19 respectively.

Recent drilling in SE. 1/4 sec. 7 and NW. 1/4 sec. 8 encountered soft water at depths of 118 and 120 feet respectively, that is under sufficient pressure to rise within 15 feet of the surface.

The village of Carroll in sec. 31 has two community wells; one, dug 30 feet through till to gravel, yields a sufficient supply of potable water except in seasons of less than normal rainfall; the other, drilled approximately 15 feet distant from the dug well, is 190 feet deep and yields salty water from a bedrock aquifer.

Township 7, Range 20. The surface of the township is flat and slopes gently toward the valley of Souris River. Silts and clays, deposited in glacial Lake Souris, cover the township. Shale outcrops along the valley of Souris River in sec. 1. South of the river from 20 to 35 feet of till overlies the bedrock. Dug wells to the top of the bedrock supply sufficient water although it is salty. Wells drilled to water-bearing zones in the bedrock also yield salty water.

Shallow dug wells are not common north of the river where most wells are drilled from 75 to 310 feet. Seventeen drilled wells are recorded, nine of which reach an aquifer that yields soft water.

Township 7, Range 21. Souris River crosses the northern half of the township and Plum Creek, flowing southeast across sec. 8, joins this river at the town of Souris. Elgin Creek and other intermittent creeks flow north across the township.

Sufficient water has not been available from the impervious overburden and wells are, therefore, drilled to aquifers in the bedrock. These wells reach water-bearing zones at depths of 75 to 222 feet and yield hard water except for a well 150 feet deep in NE. 1/4 sec. 31 that yields soft water.

The town of Souris has a municipally owned water system that supplies its population of approximately 1,500 with 40,000 gallons a day. Two wells, 195 and 85 feet deep, with a pumping capacity of 60 gallons per minute, were formerly used. The well, 85 feet deep, is beside Souris River and obtains its supply from the upper part of the fissured and weathered shale and the water probably infiltrates from the river. In 1953, a filtration plant was built and now water is pumped from Souris River, filtered, chlorinated, and distributed through the water mains.

Township 8, Range 18. That part of the township covered by end moraine is hilly, with sloughs and wooded areas. Elsewhere the township is underlain by glacial Lake Souris deposits and the surface is flat to uneven.

With few exceptions farms have enough water for 50 head of stock. The wells are from 10 to 80 feet deep and the deeper wells contain only 2 or 3 feet of water that filters slowly into the well. Water enters a well in NW. 1/4 sec. 36 through a zone of gravel at a depth of 98 feet. Test holes, to depths of as much as 190 feet, failed to encounter an aquifer in NW. 1/4 sec. 27.

Township 8, Range 19. End moraine and ice-contact stratified drift cover the greater part of this township and form an uneven to rolling surface. In small areas the drift has been modified by glacial Lake Souris and the surface is uneven to flat.

In the southwest quarter of the township wells drilled to aquifers in the bedrock, at depths of approximately 125 feet, yield potable water. Elsewhere dug wells are common and these supply water from lenses of sand or gravel in till at depths of from 12 to 80 feet. However, water in these discontinuous lenses may fail after a short period of pumping as in the twelve wells drilled from depths of from 40 to 125 feet in SW. 1/4 sec. 27. Each of the twelve wells failed within a period of 24 months. It is probable that these aquifers contained ground water trapped since the deposition of the till and replenishment could not keep pace with removal by pumping, due to the impermeability of the till.

In SW. 1/4 sec. 34, a well dug 40 feet into till reaches an artesian aquifer and the water flows at approximately 1 gallon a minute.

Township 8, Range 20. A ridge, about 1/4 mile wide and 20 feet high, extends from sec. 6 to sec. 12. Elsewhere the township is uneven to flat and was inundated by glacial Lake Souris.

Water-bearing zones, in either permeable gravel and sand or in the weathered surface of the bedrock, are reached by drilled wells 100 to 150 feet deep. Bored wells, 50 to 80 feet deep, also produce potable water from lenses of sand or gravel in the till underlying the lake deposits. Shallow dug wells fail in seasons with less than normal rainfall.

Township 8, Range 21. The surface of the township is uneven to flat and Plum Creek crosses secs. 5 and 6.

The lake deposits are somewhat permeable in this township and the water required may be encountered in dug wells approximately 25

feet deep. Drilled wells, at depths of 100 feet or more, reach aquifers within the till underlying the lake deposits or in the upper zones of the bedrock.

In 1941, eight test wells of 5 inch diameter, four in section 1 and four in section 2, were drilled at Souris Airport. The logs and resultant tests of two wells are given below and results of the other six tests follow:

	Test Boring No. 3		Test Boring No. 2
Location:	1,500 feet west of test No. 2		300 feet northwest of the south-west corner of NE. 1/4 sec. 2
Elevation:	1,450 feet (approx.)		1,450 feet (approx.)
Log:	0 to 2 feet	--- top soil ---	0 to 2 feet
	2 " 18 "	- silty buff clay -	2 " 20 "
	18 " 32 "	- bluish grey clay -	20 " 36 "
	32 " 36 "	- sand and gravel -	36 " 44 "
	36 " 45 "	- bedrock(shale) -	44 " 48 "
Depth to static water level:	4 feet from ground surface		6 feet from ground surface
Pumping test:	pumped at 12 imperial gallons per minute with stabilized level at 14 feet		pumped at 10 imperial gallons per minute with stabilized level at 15 feet 6 inches
Recovery:	complete in 25 minutes		very slow

Quality of water:
Analyses made by National Testing Laboratories, Winnipeg, Manitoba

	Test Boring No. 3	Test Boring No. 2
Calcium	257 parts per million	239 parts per million
Magnesium	90 " " "	87 " " "
Sodium	101 " " "	137 " " "
Chloride	17 " " "	16 " " "
Sulphate	682 " " "	696 " " "
Carbonate	302 " " "	306 " " "
Alkalinity	504 " " "	510 " " "
Total hardness	1,013 " " "	954 " " "
Total solids	1,449 " " "	1,481 " " "

Test boring No. 1: Total depth 62 feet. Water stood 5 feet 8 inches from the ground surface. Drawdown of 19 feet 10 inches when pumped at 15 gals. a minute.

Test boring No. 4: (36 to 44 feet, No. 2) Total depth 55 feet. The layer of sand and gravel was not encountered, instead at 34 feet the bluish clay grades into 9 feet of sandy blue clay and then into 10 feet of jumbled shale and gravel. Water stood at 34 feet from the ground surface.

Test boring No. 5: Total depth 60 feet. Coarse sand and gravel 1 foot thick was encountered at 44 feet. The well was pumped at 6 gals. a minute and the drawdown was 10 feet.

Test boring No. 6: Total depth 70 feet. The well was pumped at 6 gals. a minute with a drawdown of 15 feet and after 3 hours the level was stabilized. The water stood 19 feet from the ground surface.

Test boring No. 7: Total depth 65 feet and no supply of water.

Test boring No. 8: Total depth of 45 feet. A bed of sand 1 foot thick was encountered at a depth of 37 feet. When not pumping the water stood 1 foot from the surface of the ground with a drawdown of 10 feet 2 inches when pumped at 20 gals. a minute with complete recovery in 15 minutes.

These test wells were abandoned because of inadequate supplies and a pipe-line was built to bring water from Souris.

Township 9, Range 18. Brandon Hills, rising 250 feet above the flat surface, cover seven sections in the southwest quarter of township 9. The surface of the northeast quarter of this township slopes gently to Assiniboine River in sec. 36. Little Souris River enters the township in sec. 18 and leaves in sec. 12.

South of Assiniboine River wells, dug 40 to 70 feet deep, yield sufficient water, and elsewhere wells less than 30 feet commonly reach aquifers that yield abundant potable water. In sec. 10, two wells were drilled; one, in NE. 1/4 sec. 10, 150 feet deep, had no water and, the other, in NW. 1/4 sec. 10, 165 feet deep, yields alkaline water. The delta and fan deposits are permeable and shallow wells dug into them will yield an abundant supply of potable water.

Township 9, Range 19. Brandon Hills, covering the southeast quarter, rise 250 to 275 feet above the flat surface of the remainder of the township. Little Souris River and an intermittent tributary cross the township.

Sandy lake deposits are favourable sites for shallow wells in secs. 16 to 21 inclusive, and also in secs. 28 and 29, whereas in secs. 30 to 34, inclusive, wells are drilled to sand below glacial till. Elsewhere shallow wells are dug into the lake deposits or into the till below them.

Township 9, Range 20. The surface of this township is gently rolling to uneven and lake sands cover the northern part. Wells less than 20 feet in depth yield an abundant supply of water from the sandy beds. Elsewhere, the lake deposits are thin and wells must be extended from 50 to 90 feet into the underlying tills. Gravel underlying till at depths of 70 and 80 feet in secs. 36 and 32 yield soft water.

Township 9, Range 21. Ground moraine covers the northeast quarter of the township and elsewhere it is mantled by lake deposits except for a belt of end moraine in the southeast.

Sand, underlying lake silts and clays at a depth of 12 to 20 feet, is an excellent aquifer in the northern part of the township. A supply of water suitable only for stock is available from a zone of sand, gravel, or boulders underlying the ground moraine at depths of 80 to 100 feet. A well, in NW. 1/4 sec. 1, reaches such an aquifer in which the water is under sufficient pressure to flow from the well.

At Beresford in sec. 12, wells are dug 15 to 20 feet into sandy buff-coloured till and sufficient water can be pumped from them to satisfy the local needs.

Township 10, Range 18. Assiniboine River enters in sec. 30, flows east to sec. 21 and south to sec. 1, where it leaves the township. The surface of the township is flat to uneven, except north of Assiniboine River where the surface is hilly and rolling.

A supply of water is obtained from wells dug 15 to 20 feet into the gravel and sand of the delta and fan deposits, but the shallower wells may fail in winter months. Sandpoints are also used. Drilled wells, approximately 60 feet deep are found in secs. 9, 18, 23, 33, and 34.

Test wells were drilled in SW. 1/4 sec. 35 in search of a water supply for Chater Airport. The well completed is 13 feet deep and

water source is 5 feet of coarse sand and gravel underlying 8 feet of clay. The static level of the water is 5 feet from the surface with a drawdown of 2 feet 8 inches when pumping at a rate of 27 gallons a minute, and the recovery time is 15 minutes.

Township 10, Range 19. Assiniboine River enters the township in sec. 19 and leaves in sec. 25 following a valley more than a mile wide and with walls that rise about 100 feet above the flat valley floor.

Gravel and sand of lake, channel, delta, or fan deposits largely cover the township and are excellent aquifers into which wells are dug or driven 15 to 20 feet. At the Experimental Station a well, dug 12 feet in gravel, supplies 50 barrels of water a day. Springs along the north side of the Assiniboine Valley are also sources of water. In the southwest quarter of the township wells are drilled 60 to 90 feet deep, and these reach aquifers of sand or gravel below till that yield abundant good water.

Township 10, Range 20. The surface of the township is uneven to hilly in that part between the broad valley of Assiniboine River and the Trans Canada Highway. Lake sand and clay, covering the township south of the highway, present an uneven to flat surface except in secs. 6 and 7 where the sand forms dunes.

Dug wells, approximately 30 feet in depth, reach lenses of sand and gravel in the till beneath the lake deposits. Drilled wells, in NW. 1/4 sec. 19, NW. 1/4 sec. 20, and NE. 1/4 sec. 30, tap water-bearing gravel at depths of 80, 82, and 88 feet, respectively.

Township 10, Range 21. Ground moraine largely covers the township and forms the deposits at the surface except where covered by lake deposits in the southeast quarter. A belt of end moraine crosses secs. 21, 22, 23 and 24.

North of the Trans Canada Highway wells are dug into the ground moraine from depths of 14 to 70 feet. These wells supply sufficient water for domestic purposes and probably ten head of stock, but dugouts are needed on most farms.

Aquifers at greater depths have been penetrated by the drilled wells in secs. 5, 25, and 30. These wells reached water-bearing zones of sand and gravel at depths of 175, 70 and 90 feet, respectively, and, provided a limited supply of good water.

Analyses of Water Samples

Twenty-three samples of water from the Brandon-Souris area were analysed by the Industrial Waters Section, Mines Branch, Department of Mines and Technical Surveys, Ottawa. The sample number is for laboratory identification only.

Most of the producing wells tap aquifers in the unconsolidated deposits overlying the bedrock, therefore, only two samples from bedrock wells were collected. The total of the dissolved solids and the total of the hardness increase with depth in waters from the unconsolidated aquifers.

Sample 4050, taken from a shallow well in outwash gravel, is very hard and contains an excess of all constituents except sodium. Such a condition is not common and is probably due to contamination of the aquifer by waters from undrained depressions during periods of heavy run-off and spring flooding. This may also account for the high nitrate content.

Sample 4213 has high sodium, sulphate, and chloride, and hence has a salty taste. Sample 4057, from the drilled well at Carroll, represents ground waters from aquifers in the Riding Mountain formation. Although soft, the water has an objectionable taste due to the presence of abundant sodium, sulphate, and chloride.

Sample 4052, of Souris tap water was collected when the town water supply was pumped from wells.

ANALYSES OF WELL WATERS FROM Townships 7 to 10, Range 18, West Principal Meridian, Manitoba

								Constituents as Analysed (parts per million)								Hardness as ($CaCO_3$) (pts. per million)		
Sample Number	¼	Section	Township	Owner	Depth of well (feet)	* Aquifer	Total dissolved solids (parts per million)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Ca hardness	Mg hardness	Total hardness
4054	NW	28	7	Nesbitt Town Well	30	G.	2740	316.1	248.0	112.0	1544.5	44.3	8.9	409.7	335.8	788.7	1020.5	1809.2
4212	NE	8	8	J. Hawkins	52	S.	722	127.4	44.6	10.7	136.5	8.0	0	436.8	358.6	318.4	204.1	522.5
4051	NE	12	8	C.L. Medd	85	T.	3126	368.6	225.0	207.0	1639.7	95.2	39.9	498.7	468.8	919.7	925.9	1845.6
4056	NW	28	8	G. MacKay	40	S.	680	91.1	71.5	30.0	106.6	63.8	23.0	366.2	354.2	227.3	294.2	521.5
4137	SE	25	10	H. Tribe	18	S.	624	102.4	36.3	36.0	78.2	29.4	137.3	225.9	210.0	255.5	149.4	404.9
4159	SW	29	10	P. Johnson	33	T.	136.2	131.6	106.0	126.0	576.1	25.9	26.6	493.4	404.4	328.3	436.2	764.5

* Symbols used for aquifers G = gravel, S = sand, T = glacial till.

ANALYSES OF WELL WATERS FROM Townships 7 to 10, Range 19, West Principal Meridian, Manitoba

								Constituents as Analysed (parts per million)								Hardness as ($CaCO_3$) (pts. per million)		
Sample Number	¼	Section	Township	Owner	Depth of well (feet)	Aquifer*	Total dissolved solids (parts per million)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Ca hardness	Mg hardness	Total hardness
4055	SE	4	7	F. Seafoot	80	G.	1786	247.9	76.5	165.0	884.0	21.6	8.9	415.0	340.2	618.5	314.0	932.5
4213	NW	8	7	E.A. Roberts	120	S.	1513	10.2	4.8	600.0	462.1	175.0	0	710.0	532.0	25.4	19.8	45.2
4211	SE	31	7	Carroll dug well	30	G.	636	101.3	50.3	320.0	150.2	56.9	63.8	358.7	294.0	252.7	207.8	460.5
4057	SE	31	7	" drilled "	190	Sh.	1486	20.1	21.3	515.0	306.2	451.2	4.4	240.4	251.4	50.1	87.6	137.7
4050	NE	23	8	R. Hine	35	G.	2104	183.1	270.0	13.0	207.4	165.4	579.4	735.9	619.6	456.8	1111.1	1567.9
4053	SW	27	8	J.R.Cunningham	63	S.	1208	250.8	54.4	23.0	487.9	4.7	0	540.5	443.0	625.7	223.9	849.6
4134	NE	27	9	A. Mowat	37		732	66.7	81.1	31.2	307.4	14.7	21.3	227.4	202.4	166.4	333.7	500.1
4160	NE	33	9	R. Brown	100	S.	650	71.4	32.8	90.0	95.9	9.1	4.7	512.2	419.8	178.1	135.0	313.1
4162	SW	30	10	P.G. Marsden	16	G.	1172	134.0	90.9	112.0	402.9	42.0	5.3	566.1	464.0	334.3	374.1	708.4

* Symbols used for aquifers G = gravel, S = sand, Sh = Riding Mountain shale.

ANALYSES OF WELL WATERS FROM Townships 7 to 10, Ranges 20 and 21, West Principal Meridian, Manitoba

Sample Number	¼	Section	Township	Owner	Depth of well (feet)	* Aquifer	Total dissolved solids (parts per million)	Constituents as Analysed (parts per million): Calcium (Ca)	Magnesium Mg	Alkalis (as Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Hardness as($CaCO_3$) (pts. per million): Ca hardness	Mg hardness	Total hardness
4135	NW	14	8	J. Lovatt	73	Sh.	2085	112.5	50.7	552.0	889.3	108.5	0	663.7	544.0	280.7	208.6	489.3
4158	NW	1	10	A. Clark	27		688	53.2	23.4	156.0	144.0	53.9	0	417.2	342.0	132.7	96.3	229.0
4138	NW	12	10	J.A. Irving	61	S.	1904	295.0	90.0	128.0	993.4	21.7	0	412.1	337.8	736.0	370.4	1106.4
4136	NW	19	10	W.S. Carnahan	85	S.	1614	241.6	108.4	77.0	689.7	33.6	0	585.8	480.2	602.8	446.1	1048.9
Range 21																		
4052	NW	34	7	Souris Tap Water			1430	38.5	13.8	495.0	202.9	385.4	8.0	444.6	474.4	96.1	56.8	152.9
4163	SW	10	9	R. Johnson	90	G.	4048	366.3	247.4	470.0	2005.0	243.6	0	590.5	484.0	913.9	1018.1	1932.0
4161	NE	21	9		80	G.	4252	641.0	199.5	98.0	1592.2	135.8	673.4	350.9	287.6	1599.3	820.9	2420.2
4133	SE	19	10	G. Speers	55	S.	1460	271.8	106.0	16.4	572.4	72.7	10.6	534.6	438.2	678.1	436.2	1114.3

* Symbols used for aquifers G = gravel, S = sand, Sh = Riding Mountain shale.

Record of Wells

The following table of well records has been prepared from drillers' records and data collected by the Geological Survey. The following abbreviations are used:

Sec.	Section
Drl.	Drilled well
Brd.	Bored well
R.M.	Riding Mountain formation
Dom.	Domestic use
Stk.	Stock use
Not	Not used
#	Well from which a sample was taken

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 7, Range 18

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of water	Use	Remarks
2	NW	Dug	1,377	23	5	Till	Hard	Stk.	Sufficient for 30 head
3	NW	Dug	1,435	29	15	Drift	Hard	Dom. Stk.	
4	NE	Dug	1,433	31	14	Sand	Hard	Dom. Stk.	Sufficient for 40 head
6	SE	Dug	1,477	50	12	Drift	Hard	Dom. Stk.	Sufficient for 5 head
7	NE	Dug	1,462	32	11	Till	Hard	Dom. Stk.	Sufficient for 15 head
10	SW	Dug	1,393	17	4	Sand	Hard	Dom. Stk.	Sufficient for 60 head
11	SW	Dug	1,385	27	18	Gravel	Hard	Dom.	
12	NW	Dug	1,358	24	12	Drift	Hard	Stk.	Sufficient for 12 head
13	SW	Dug	1,364	31	22	Till	Hard	Dom.	Dry in summer months
15	NE	Dug	1,387	19	5	Drift	Hard	Dom. Stk.	Sufficient for 25 head
16	SW	Drl.	1,320	200	9	-	Hard	Dom. Stk.	
18	SW	Dug	1,466	40	34	Gravel	Hard	Stk.	Sufficient for 50 head
19	NW	Dug	1,460	43	36	Sand	Hard	Dom. Stk.	Sufficient for 25 head
20	SE	Dug	1,437	33	11	Gravel	Hard	Dom.	Well for stock 36 feet deep
21	NW	Dug	1,431	21	13	Sand	Hard	Dom. Stk.	Sufficient supply
22	NW	Dug	1,402	50	40	Till	Hard	Dom.	Also a drilled well 130 feet deep
23	SE	Dug	1,355	33	11	Sand	Hard	Stk.	Waters 30 head of stock
24	NE	Dug	1,334	30	10	Gravel	Hard	Stk.	Waters 20 head of stock
25	NW	Brd.	1,332	58	10	Drift	Hard	Dom. Stk.	Sufficient for 30 head
26	NE	Dug	1,321	12	6	Sand	Hard	Stk.	
27	SW	Dug	1,393	18	15	Sand	Hard	Dom. Stk.	Sufficient for 35 head
28	NW	Dug	1,410	30	25	Till	Hard	Dom. Stk.	Well at Nesbitt, Man.
30	SE	Dug	1,460	31	21	Gravel	Hard	Dom.	Sufficient supply
32	NW	Dug	1,433	30	18	Gravel	Hard	Dom. Stk.	Sufficient for 35 head
33	NW	Dug	1,413	24	9	Gravel	Hard	Dom. Stk.	Sufficient for 50 head
34	SW	Dug	1,376	32	10	Till	Hard	Dom. Stk.	
35	SW	Dug	1,364	32	24	Till	Hard	Dom. Stk.	Sufficient for 35 head
36	SE	Dug	1,306	14	4	Till	Hard	Dom. Stk.	
36	SW	Dug	1,320	15	5	Drift	Hard	Dom. Stk.	Sufficient for 20 head

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 7, Range 19

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of water	Use	Remarks
1	NE	Dug	1,491	40	33	Sand	Hard	Dom. Stk.	Sufficient for 40 head
2	SW	Dug	1,549	46	24	Gravel	Hard	Not.	
4	SE	Brd.	1,551	80	30	Gravel	Hard	Dom. Stk.	Sufficient for 75 head
7	SE	Drl.	1,479	118	10	RM	Soft	Stk.	
8	NW	Drl.	1,501	120	15	RM	Soft	Dom. Stk.	
9	NW	Brd.	1,604	55	10	Sand	Hard	Dom. Stk.	Sufficient for 15 head
10	NW	Brd.	1,569	100	30	-	Hard	Dom. Stk.	
11	SE	Brd.	1,528	60	30	Sand	Hard	Dom. Stk.	Sufficient for 80 head
12	SE	Brd.	1,467	80	20	Sand	Hard	Dom. Stk.	Sufficient for 40 head
13	SE	Dug	1,482	50	25	Drift	Hard	Stk.	Sufficient for 20 head
14	SE	Dug	1,496	30	15	Drift	Hard	Dom. Stk.	
16	SE	Dug	1,567	41	11	Drift	Hard	Dom. Stk.	Sufficient for 50 head
17	SW	Drl.	1,579	128	55	Sand	Hard	Dom. Stk.	Sufficient for 30 head
18	NE	Drl.	1,573	100	40	Sand	Hard	Dom. Stk.	Sufficient for 20 head
21	SE	Brd.	1,560	52	20	Till	Hard	Dom. Stk.	Sufficient for 50 head
22	SW	Dug	1,516	28	8	Sand	Hard	Dom. Stk.	Sufficient for 30 head
22	SE	Dug	1,505	26	10	Drift	Hard	Dom. Stk.	Sufficient for 75 head
23	SE	Dug	1,466	23	12	Drift	Hard	Dom. Stk.	Stock well 45 feet deep
25	NW	Dug	1,500	25	20	Gravel	Hard	Dom. Stk.	Sufficient for 20 head
26	SW	Dug	1,482	20	9	Drift	Hard	Dom.	
27	SE	Dug	1,508	25	20	Gravel	Hard	Dom. Stk.	Sufficient for 25 head
29	NW	Dug	1,480	18	9	Gravel	Hard	Dom. Stk.	Sufficient for 50 head
30	NW	Drl.	1,498	160	-	Gravel	Hard	Dom. Stk.	Sufficient for 40 head
31	SW	Drl.	1,488	42	25	Sand	Hard	Dom. Stk.	Sufficient for 35 head
31	SE	Dug	1,497	40	25	Gravel	Hard	Dom. Stk.	
33	SE	Dug	1,543	21	7	Till	Hard	Dom. Stk.	Sufficient for 40 head
36	SW	Dug	1,493	14	13	Drift	Hard	Dom. Stk.	

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 7, Range 20

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of water	Use	Remarks
1	SW	Dug	1,414	26	20	Till	Hard	Dom. Stk.	
3	SE	Dug	1,481	30	23	RM	Hard	Stk.	
4	SE	Dug	1,462	35	7	RM	Hard	Dom. Stk.	Drilled a well 310 feet deep
5	NE	Dug	1,440	30	10	RM	Hard	Stk.	Salty water
6	NW	Drl.	1,373	130	30	RM	Hard	Stk.	Water is salty
6	SE	Dug	1,481	21	12	RM	Hard	-	
8	NW	Drl.	1,453	75	15	RM	Hard	Stk.	House well 17 feet deep
13	NW	Drl.	1,489	180	30	RM	Soft	Dom. Stk.	
15	NW	Drl.	1,427	68	20	RM	Soft	Dom. Stk.	Sufficient for 30 head
18	NW	Dug	1,430	21	14	Till	Hard	Not.	Temperature of water 42°F.
20	NW	Drl.	1,432	85	-	Till	Hard	Dom. Stk.	
23	NE	Dug	1,483	31	23	Till	Hard	Dom.	
23	SE	Drl.	1,493	180	33	RM	Soft	Dom.	
24	NE	Drl.	1,497	180	40	RM	Soft	Dom. Stk.	
25	NE	Dug	1,475	17	13	Sand	Hard	Dom. Stk.	Sufficient for 100 head
26	NW	Drl.	1,492	85	15	RM	Hard	Dom. Stk.	
27	SW	Drl.	1,496	150	-	RM	Soft	Dom. Stk.	
28	NE	Drl.	1,482	125	40	RM	Soft	Dom. Stk.	Salty
29	NE	Drl.	1,460	147	-	RM	Hard	Not.	
30	NE	Drl.	1,448	110	15	RM	Hard	Dom. Stk.	Water at 100 feet in shale
31	SE	Drl.	1,456	100	35	RM	Soft	Dom. Stk.	Sufficient for 35 head
32	SE	Drl.	1,477	150	60	RM	Soft	Dom.	Sufficient for 100 head
32	NW	Drl.	1,468	75	30	RM	Hard	Dom. Stk.	
33	NW	Brd.	1,478	36	-	Till	Hard	Dom. Stk.	Sufficient for 60 head
34	NW	Dug	1,521	24	14	Sand	Hard	Stk.	Sufficient for 10 head
34	SE	Drl.	1,511	240	30	RM	Soft	Dom. Stk.	
35	SW	Drl.	1,495	75	-	RM	Hard	Dom. Stk.	
36	SW	Dug	1,498	30	20	Till	Hard	Dom. Stk.	Sufficient for 50 head

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 7, Range 21

Sec.	1/4	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of water	Use	Remarks
2	NE	Dug	1,442	20	9	Till	Hard	Dom.	
2	SE	Dug	1,453	24	21	Till	Hard	Dom.	Temperature of water 43°F.
4	NE	Dug	1,440	22	13	Till	Hard	Dom.	Drilled well for stock
4	SE	Drl.	1,446	135	17	RM	Hard	Stk.	Bedrock at 135 feet
6	SW	Dug	1,489	20	18	Till	Hard	Dom.	Bedrock at 135 feet
6	SW	Drl.	1,450	113	-	RM	Hard	Stk.	Salty water. Bedrock at 113 feet
7	NE	Dug	1,430	14	10	Till	Hard	Dom.	
8	SE	Drl.	1,525	222	16	?	Hard	Stk.	Temperature of water 42°F.
8	NE	Drl.	1,425	140	-	?	Hard	Dom. Stk.	Bedrock at 140 feet
9	SW	Dug	1,446	14	10	Till	Hard	Dom. Stk.	Temperature of water 42°F.
10	NE	Dug	1,450	32	16	Till	Hard	Dom.	Iron precipitate in the water
12	NE	Dug	1,440	11	5	Gravel	Soft	Dom.	
13	NE	Drl.	1,412	190	-	-	Hard	Stk.	Salty water; bedrock at 190 feet
14	SW	Drl.	1,408	90	18	Drift	Hard	Stk.	
14	NW	Dug	1,418	35	18	Till	Hard	Dom.	Alkali water
15	NE	Dug	1,410	24	12	Till	Hard	Dom.	
16	NE	Dug	1,438	16	13	Till	Hard	Dom.	
17	NE	Drl.	1,422	75	18	Till	Hard	Dom.	Not sufficient
18	SE	Drl.	1,425	85	15	Till	Hard	Stk.	Salty water
18	NW	Drl.	1,430	170	-	-	Hard	Stk.	Bedrock at 170 feet.
19	NW	Drl.	1,418	160	35	-	Soft	Dom. Stk.	Salty water
20	SE	Dug	1,420	36	26	Till	Hard	Dom. Stk.	
22	NE	Dug	1,390	15	12	Till	Hard	Dom.	
23	NE	Dug	1,403	31	13	Till	Hard	Dom. Stk.	Alkali water
26	SW	Dug	1,400	25	5	Till	Hard	Dom.	
31	SE	Dug	1,428	25	22	Gravel	Hard	Dom. Stk.	Temperature of water 41°F.
31	NE	Drl.	1,412	150	40	RM	Soft	Dom. Stk.	Bedrock at 70 feet
34	NW	Dug	1,390	22	15	Gravel	Hard	Dom. Stk.	

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 8, Range 18

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of water	Use	Remarks
1	SW	Dug	1,366	25	10	Sand	Hard	Dom. Stk.	Sufficient for 30 head
2	NE	Dug	1,367	16	9	Drift	Hard	Dom. Stk.	
4	SW	Dug	1,410	65	40	Till	Hard	Dom. Stk.	Sufficient for 60 head
5	NW	Dug	1,453	30	24	Sand	Hard	Dom. Stk.	Sufficient for 50 head
6	SW	Dug	1,474	23	12	Drift	Hard	Dom. Stk.	Sufficient for 20 head
8	NE	Dug	1,486	52	50	Sand	Hard	Dom. Stk.	Sufficient for 20 head
8	SW	Dug	1,459	32	27	Gravel	Hard	Dom. Stk.	
9	NE	Dug	1,462	34	30	Sand	Hard	Dom. Stk.	Sufficient for 80 head
9	SE	Dug	1,450	24	22	Sand	Hard	Dom. Stk.	
9	NE	Dug	1,462	35	32	Sand	Hard	Dom. Stk.	Sufficient for 60 head
10	SE	Dug	1,427	15	9	Till	Hard	Dom. Stk.	Sufficient for 20 head
11	SE	Dug	1,378	13	5	Gravel	Hard	Dom. Stk.	
12	SW	Dug	1,346	24	22	Drift	Hard	Dom. Stk.	Well dug in 1897
12	NE	Drl.	1,328	85	20	Till	Hard	Dom. Stk.	Sufficient for 60 head
14	SE	Drl.	1,342	75	30	Till	Hard	Dom. Stk.	Sufficient for 50 head
15	NE	Dug	1,369	14	8	Gravel	Hard	Dom. Stk.	Sufficient for 150 head
16	NW	Dug	1,470	32	29	Gravel	Hard	Dom. Stk.	Sufficient for 60 head
17	SE	Dug	1,503	75	72	Gravel	Hard	Dom. Stk.	Sufficient for 60 head
19	SE	Dug	1,458	36	32	Sand	Hard	Dom. Stk.	Sufficient for 50 head
20	NW	Dug	1,461	29	27	Sand	Hard	Dom. Stk.	
22	NE	Dug	1,486	40	25	RM	Hard	Stk.	Bedrock at 40 feet
22	SE	Dug	1,349	42	8	Till	Hard	Dom. Stk.	Sufficient for 10 head
24	NW	Dug	1,303	83	20	Sand	Hard	Dom. Stk.	Sufficient for 300 head
24	SE	Drl.	1,310	70	30	Till	Hard	Stk.	Sufficient for 50 head
28	NW	Brd.	1,401	40	25	Sand	Hard	Dom.	
30	SE	Brd.	1,419	24	6	Drift	Hard	Dom. Stk.	
31	SE	Dug	1,426	30	24	Drift	Hard	Dom. Stk.	
36	NE	Dug	1,278	50	39	Gravel	Hard	Dom. Stk.	
36	NW	Dug	1,281	98	40	Gravel	Hard	Dom. Stk.	Sufficient for 50 head

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 8, Range 19

Sec.	$\frac{1}{4}$	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of water	Use	Remarks
3	SE	Dug	1,530	36	21	Drift	Hard	Dom. Stk,	Sufficient for 30 head
4	NW	Dug	1,518	27	19	Sand	Hard	Dom. Stk.	Sufficient for 30 head
5	NE	Dug	1,511	18	6	Gravel	Hard	Dom. Stk	Sufficient for 20 head
6	NE	Drl.	1,529	160	10	-	Hard	Dom. Stk.	Sufficient for 90 head
7	NE	Drl.	1,507	120	-	RM	Soft	Dom. Stk.	Sufficient for 12 head
8	NE	Dug	1,491	14	9	Till	Hard	Dom. Stk.	Sufficient for 35 head
10	NE	Dug	1,511	16	8	Sand	Hard	Dom. Stk.	Sufficient for 40 head
15	NE	Dug	1,528	50	45	Gravel	Hard	Dom. Stk.	Sufficient for 70 head
15	SW	Dug	1,523	34	27	Gravel	Soft	Dom.	
16	SE	Dug	1,516	26	22	Gravel	Hard	Dom.	Well at barn 21 feet deep
17	SE	Drl.	1,496	112	22	RM	Soft	Dom. Stk.	Bedrock at 90 feet
18	SW	Drl.	1,512	140	-	RM	Soft	Dom. Stk.	Sufficient for 30 head
18	NE	Brd.	1,491	40	32	Sand	Hard	Dom. Stk.	Sufficient for 20 head
19	NE	Dug	1,461	26	16	Sand	Hard	Dom. Stk.	Sufficient for 90 head
20	NE	Dug	1,466	32	19	Sand	Hard	Dom. Stk.	
20	SE	Dug	1,504	55	50	Sand	Hard	Dom. Stk.	Sufficient for 30 head
23	NE	Brd.	1,469	35	27	Gravel	Hard	Dom. Stk.	
24	NW	Dug	1,453	11	8	Gravel	Hard	Dom. Stk.	Sufficient for 30 head
26	NW	Brd.	1,482	80	30	Drift	Hard	Dom. Stk.	
26	NE	Dug	1,502	20	17	Till	Hard	Dom. Stk.	
27	SE	Dug	1,521	63	60	Sand	Hard	Dom. Stk.	Not sufficient
28	SE	Brd.	1,488	56	28	Sand	Hard	Dom. Stk.	Sufficient for 25 head
30	SE	Brd.	1,444	12	9	Till	Hard	Dom. Stk.	Sufficient for 40 head
31	SE	Brd.	1,381	40	20	Sand	Hard	Dom.	Stock well 50 feet deep
32	NE	Dug	1,418	18	3	Drift	Hard	Dom. Stk.	
34	SW	Dug	1,407	40	-	Drift	Hard	Dom. Stk.	Well flows
34	SE	Brd.	1,457	70	55	Sand	Hard	Dom. Stk.	Sufficient for 30 head
35	NW	Brd.	1,461	60	50	Sand	Hard	Dom. Stk.	Sufficient for 10 head
36	NE	Dug	1,443	21	7	Gravel	Hard	Dom. Stk.	Sufficient for 50 head

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 8, Range 20

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of water	Use	Remarks
1	SE	Dug	1,514	19	14	Till	Hard	Dom. Stk.	
2	SW	Dug	1,520	22	15	Till	Hard	Dom. Stk.	Sufficient for 10 head
3	SW	Dug	1,501	26	12	Sand	Hard	Dom. Stk.	
4	NW	Drl.	1,524	110	-	Sand	Hard	Dom. Stk.	Sufficient for 35 head
5	NW	Drl.	1,513	110	-	Sand	Hard	Dom. Stk.	
6	SE	Drl.	1,490	80	-	Till	Hard	Dom. Stk.	
7	SE	Drl.	1,513	110	40	Till	Hard	Dom. Stk.	
8	NW	Brd.	1,511	80	60	Till	Hard	Dom. Stk.	Sufficient for 35 head
10	SE	Brd.	1,543	60	30	Till	Hard	Dom. Stk.	
11	SE	Drl.	1,543	100	37	Sand	Hard	Dom. Stk.	
12	SW	Drl.	1,537	115	45	Sand	Hard	Dom. Stk.	Sufficient for 100 head
13	NE	Brd.	1,462	34	23	Gravel	Hard	Dom. Stk.	Sufficient for 45 head
14	SE	Drl.	1,443	105	24	RM	Soft	Dom. Stk.	
14	NW	Drl.	1,459	73	40	RM	Hard	Dom.	Sufficient supply
16	SE	Brd.	1,500	50	30	Till	Hard	Dom. Stk.	
17	SW	Drl.	1,502	150	50	RM	Hard	Dom. Stk.	
18	NW	Brd.	1,477	60	30	Till	Hard	Dom. Stk.	
19	SW	Brd.	1,472	55	30	Gravel	Hard	Dom. Stk.	Sufficient for 30 head
20	NE	Drl.	1,439	150	-	RM	Hard	Dom. Stk.	
21	SW	Brd.	1,455	72	52	Till	Hard	Dom. Stk.	
22	NE	Brd.	1,468	43	27	Till	Hard	Dom. Stk.	
23	SE	Drl.	1,449	156	60	Till	Hard	Dom. Stk.	
26	SW	Dug	1,417	26	16	Till	Hard	Dom. Stk.	
28	SW	Brd.	1,441	68	43	Till	Hard	Dom. Stk.	Sufficient for 30 head
30	SW	Dug	1,451	40	34	Sand	Hard	Dom. Stk.	Sufficient for 30 head
31	SE	Dug	1,444	40	15	Till	Hard	Dom. Stk.	Sufficient supply
32	NE	Dug	1,400	34	26	Till	Hard	Dom. Stk.	Sufficient for 60 head
33	SE	Drl.	1,422	112	20	Till	Soft	Dom. Stk.	

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 8, Range 21

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of water	Use	Remarks
1	SW	Dug	1,443	15	6	Till	Hard	Stk.	
2	NW	Brd.	1,433	33	15	Gravel	Hard	Dom. Stk.	Sufficient for 100 head
4	NE	Dug	1,393	16	6	Gravel	Hard	Dom.	Stock well dug 10 feet deep
5	SE	Dug	1,406	13	3	Sand	Hard	Dom. Stk.	
6	SE	Drl.	1,388	116	26	RM	Soft	Dom. Stk.	Bedrock at 116 feet
9	SE	Dug	1,397	13	10	Gravel	Hard	Dom.	Three such wells
10	SW	Drl.	1,394	86	3	RM	Hard	Stk.	Sufficient for 100 head
11	NE	Drl.	1,445	100	16	RM	Soft	Stk.	Bedrock at 90 feet
12	SE	Drl.	1,497	103	40	RM	Hard	Dom. Stk.	
13	SW	Dug	1,460	45	14	Till	Hard	Dom.	
14	SW	Brd.	1,432	90	80	Till	Hard	Dom. Stk.	
15	SE	Drl.	1,427	119	-	RM	Hard	Stk.	Salty water
16	NE	Dug	1,412	45	11	Till	Hard	Dom. Stk.	Sufficient for 190 head
18	NW	Dug	1,424	13	3	Sand	Hard	Dom. Stk.	
21	SE	Drl.	1,420	153	25	RM	Hard	Dom. Stk.	Sufficient for 50 head
24	SW	Drl.	1,459	157	70	RM	Hard	Dom. Stk.	Sufficient for 40 head
25	SE	Dug	1,454	50	31	Gravel	Hard	Dom. Stk.	
26	SE	Drl.	1,451	117	20	Till	Hard	Dom. Stk.	
27	SW	Drl.	1,435	160	-	RM	Hard	Stk.	Salty water
28	SE	Drl.	1,418	90	50	Till	Hard	Dom. Stk.	
28	NE	Dug	1,443	53	6	Till	Hard	Stk.	
30	NE	Dug	1,421	19	13	Sand	Hard	Dom. Stk.	Alkali water
31	NW	Drl.	1,426	152	40	Gravel	Hard	Dom. Stk.	Salty water
33	SE	Dug	1,440	65	30	Till	Hard	Dom. Stk.	

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 9, Range 18

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of Water	Use	Remarks
1	NE	Dug	1,234	50	40	Drift	Hard	Stk.	Sufficient for 75 head
2	NE	Dug	1,267	41	32	Drift	Hard	Dom. Stk.	
3	NW	Dug	1,330	40	-	Sand	Hard	Stk.	Sufficient for 30 head
9	SE	Brd.	1,268	42	24	Sand	Hard	Dom. Stk.	
9	NW	Dug	1,273	25	21	Sand	Hard	Dom.	
10	NE	Dug	1,253	25	20	Sand	Hard	Dom. Stk.	
10	NW	Drl.	1,253	165	-	Till	Hard	Stk.	Domestic well 30 feet deep
11	SW	Drl.	1,231	40	-	Till	Hard	Dom. Stk.	Sufficient for 50 head
11	SW	Dug	1,262	70	65	Till	Hard	Dom.	
16	SW	Dug	1,284	30	26	Till	Hard	Dom.	
17	SE	Dug	1,280	39	29	Till	Hard	Dom. Stk.	
18	NW	Dug	1,285	30	20	Sand	Hard	Dom.	
19	SW	Dug	1,266	17	12	Sand	Hard	Dom. Stk.	Sufficient for 70 head
19	NE	Dug	1,287	27	18	Sand	Hard	Dom. Stk.	
20	NW	Dug	1,290	29	18	Drift	Hard	Dom. Stk.	
21	SW	Dug	1,287	18	5	Sand	Hard	Dom. Stk.	
21	NE	Dug	1,226	9	6	Sand	Hard	Dom. Stk.	
22	NE	Dug	1,212	14	9	Gravel	Hard	Dom. Stk.	Sufficient for 50 head
24	SE	Dug	1,203	22	10	Gravel	Hard	Dom. Stk.	
25	NE	Dug	1,183	26	10	Gravel	hard	Dom. Stk.	
26	SW	Dug	1,211	8	5	Sand	hard	Stk.	
27	SW	Dug	1,226	10	6	Sand	hard	Dom. Stk.	Sufficient for 50 head
29	NE	Drl.	1,259	45	25	Sand	Hard	Dom. Stk.	Sufficient for 60 head
29	SE	Dug	1,282	62	30	Sand	Hard	Dom. Stk.	
30	SE	Dug	1,303	40	35	Sand	Hard	Dom. Stk.	Stock well 30 feet deep
30	NE	Dug	1,271	20	15	Sand	Hard	Dom.	
31	NE	Dug	1,271	35	30	Sand	Hard	Dom. Stk.	
31	NW	Dug	1,296	32	27	Sand	Hard	Dom. Stk.	
32	NW	Dug	1,262	53	-	Drift	Hard	Dom. Stk.	
33	SE	Dug	1,222	41	13	Drift	Hard	Dom.	Stock well 28 feet deep

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 9, Range 19

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of Water	Use	Remarks
2	NW	Dug	1,434	18	4	Sand	Hard	Dom. Stk.	Sufficient for 60 head
3	NE	Dug	1,431	32	30	Gravel	Hard	Dom. Stk.	
4	SE	Dug	1,356	42	2	Drift	Hard	Dom. Stk.	
6	NE	Dug	1,333	68	56	Gravel	Soft	Dom.	Drilled a dry hole 550 feet
7	NE	Dug	1,347	40	20	Sand	Hard	Dom. Stk.	Sufficient for 50 head
8	NW	Brd.	1,329	65	25	Sand	Hard	Dom. Stk.	
11	NE	Dug	1,375	24	15	Till	Hard	Dom. Stk.	
13	NW	Dug	1,307	19	14	Drift	Hard	Dom.	
14	SW	Drl.	1,323	67	22	Till	Hard	Dom.	
16	NW	Dug	1,308	27	7	Gravel	Hard	Dom. Stk.	Sufficient for 100 head
17	SW	Dug	1,330	13	5	Till	Soft	Dom. Stk.	
18	NE	Dug	1,337	45	20	Gravel	Hard	Dom. Stk.	Sufficient for 80 head
20	SE	Dug	1,339	46	20	Sand	Hard	Dom. Stk.	
21	NE	Dug	1,354	30	20	Gravel	Hard	Dom. Stk.	Sufficient for 35 head
22	SE	Dug	1,316	57	16	Sand	Hard	Dom. Stk.	Sufficient for 75 head
23	SW	Dug	1,332	15	12	Drift	Hard	Dom. Stk.	
24	SE	Dug	1,272	25	11	Sand	Hard	Dom. Stk.	
25	NE	Dug	1,312	36	34	Sand	Hard	Dom. Stk.	
26	NW	Brd.	1,311	56	32	Drift	Hard	Dom. Stk.	Also a well 31 feet deep
27	NE	Drl.	1,308	40	15	Drift	Hard	Dom. Stk.	Sufficient for 40 head
28	SE	Dug	1,342	40	30	Gravel	Hard	Dom. Stk.	Sufficient for 100 head
29	NW	Dug	1,345	40	25	Gravel	Hard	Dom. Stk.	Sufficient for 25 head
30	NW	Drl.	1,359	55	30	Drift	Hard	Dom. Stk.	Sufficient for 40 head
31	SE	Drl.	1,339	50	20	Gravel	Hard	Dom. Stk.	Sufficient for 35 head
32	NE	Drl.	1,330	110	15	Sand	Hard	Dom. Stk.	Sufficient for 80 head
33	NE	Drl.	1,318	100	30	Sand	Hard	Stk.	
34	NE	Drl.	1,315	85	60	Gravel	Hard	Dom. Stk.	Sufficient for 100 head
36	NE	Dug	1,273	16	12	Sand	Hard	Dom. Stk.	

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 9, Range 20

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of Water	Use	Remarks
2	NW	Brd.	1,377	57	28	Till	Hard	Dom. Stk.	Sufficient for 25 head
2	SW	Dug	1,366	90	30	Till	Hard	Dom. Stk.	Sufficient for 20 head
3	NW	Dug	1,397	25	20	Sand	Hard	Dom. Stk.	Sufficient for 25 head
4	NE	Dug	1,392	70	10	Drift	Hard	Dom. Stk.	Sufficient for 50 head
6	NW	Dug	1,420	10	7	Sand	Hard	Dom. Stk.	Sufficient for 30 head
7	SW	Dug	1,421	50	25	Sand	Hard	Dom. Stk.	
8	SW	Dug	1,401	16	12	Sand	Hard	Dom. Stk.	Sufficient for 40 head
9	SE	Dug	1,390	10	6	Sand	Hard	Dom. Stk.	Sufficient for 60 head
10	SE	Dug	1,395	20	15	Sand	Hard	Dom. Stk.	
11	NE	Brd.	1,390	39	4	Drift	Hard	Dom.	
12	NW	Brd.	1,361	50	30	Sand	Hard	Dom. Stk.	Sufficient for 35 head
12	NE	Dug	1,359	28	8	Sand	Hard	Dom. Stk.	Sufficient for 40 head
13	NW	Dug	1,356	15	7	Sand	Hard	Dom. Stk.	
14	SW	Dug	1,396	14	10	Sand	Hard	Dom.	
15	SW	Dug	1,397	15	7	Sand	Hard	Dom. Stk.	Sufficient for 70 head
16	NE	Dug	1,399	18		Sand	Hard	Not.	
18	SW	Drl.	1,391	120	12		Hard	Stk.	Alkali water
19	SW	Dug	1,372	35	6	Gravel	Hard	Dom.	
22	NE	Dug	1,331	20	10	Sand	Hard	Dom. Stk.	
25	SW	Dug	1,365	20	18	Sand	Hard	Dom. Stk.	Sufficient for 30 head
26	NE	Dug	1,368	22	19	Sand	Hard	Dom. Stk.	Sufficient for 50 head
27	SW	Dug	1,352	20	10	Sand	Hard	Dom. Stk.	Sufficient for 100 head
28	SE	Dug	1,356	11	5	Sand	Hard	Dom. Stk.	Sufficient for 100 head
29	SE	Dug	1,366	10	7	Sand	Hard	Dom. Stk.	Sufficient for 100 head
32	NW	Dug	1,398	22	17	Sand	Hard	Dom. Stk.	
33	NE	Brd.	1,365	23	18	Sand	Hard	Dom. Stk.	
34	NE	Drl.	1,363	90	20	Till	Hard	Dom. Stk.	
35	NE	Dug	1,380	22	18	Sand	Hard	Dom. Stk.	Sufficient for 50 head
36	SE	Drl.	1,367	60	45	Drift	Hard	Stk.	Domestic well 25 feet deep

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 9, Range 21

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of Water	Use	Remarks
1	NE	Brd.	1,413	90	50	Till	Hard	Stk.	Sufficient for 40 head
2	NE	Brd.	1,425	90	10	Till	Hard	Dom. Stk.	Sufficient for 15 head
4	NW	Drl.	1,424	46	25	Sand	Hard	Dom. Stk.	Sufficient for 35 head
4	NE	Drl.	1,431	90	30	Gravel	Hard	Dom. Stk.	Sufficient for 50 head
5	SE	Drl.	1,427	80	25	Sand	Hard	Dom. Stk.	Sufficient for 50 head
8	NW	Drl.	1,456	95	75	Till	Hard	Dom. Stk.	
9	SE	Brd.	1,427	86	46	Gravel	Hard	Dom. Stk.	Sufficient for 40 head
10	SE	Dug	1,430	90	65	Gravel	Hard	Dom. Stk.	Sufficient for 50 head
11	SW	Brd.	1,417	90	35	Till	Hard	Dom. Stk.	Sufficient for 60 head
13	SW	Dug	1,398	14	10	Gravel	Hard	Dom. Stk.	Sufficient for 15 head
15	SE	Dug	1,404	12	6	Sand	Hard	Dom. Stk.	
15	NE	Brd.	1,391	80	50	Gravel	Hard	Dom. Stk.	Sufficient for 100 head
16	NW	Brd.	1,421	60	30	Till	Hard	Dom. Stk.	
18	SW	Dug	1,446	35	20	Sand	Hard	Dom. Stk.	
19	NE	Drl.	1,425	160	-	Sand	Hard	Dom.	Not sufficient
21	NE	Dug	1,396	80	15	Gravel	Hard	Dom. Stk.	Sufficient for 50 head
22	NE	Dug	1,390	12	8	Till	Hard	Dom.	Sufficient supply
222	SW	Brd.	1,401	90	-	Till	Hard	Not.	Alkali water
24	NE	Dug	1,387	16	11	Sand	Hard	Dom. Stk.	Sufficient for 30 head
26	NW	Dug	1,393	20	10	Till	Hard	Dom. Stk.	Sufficient for 25 head
26	NE	Dug	1,383	12	2	Sand	Hard	Dom. Stk.	Sufficient for 30 head
27	NE	Dug	1,391	14	6	Sand	Hard	Dom. Stk.	
30	NW	Dug	1,424	26	7	Sand	Hard	Dom. Stk.	
31	NW	Brd.	1,429	114	15	Gravel	Hard	Dom. Stk.	
33	SE	Dug	1,402	30	26	Sand	Hard	Dom. Stk.	Sufficient for 40 head
33	NE	Dug	1,401	14	11	Sand	Hard	Dom. Stk.	Sufficient for 30 head
34	SW	Dug	1,404	20	-	Sand	Hard	Stk.	Sufficient for 30 head
35	SW	Dug	1,393	26	6	Sand	Hard	Dom. Stk.	
35	NW	Dug	1,393	15	10	Sand	Hard	Dom. Stk.	Sufficient for 15 head

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 10, Range 18

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of Water	Use	Remarks
4	NE	Dug	1,227	21	7	Sand	Hard	Dom. Stk.	
5	NE	Dug	1,272	12	7	Sand	Hard	Dom. Stk.	
6	NW	Dug	1,276	12	8	Sand	Hard	Dom. Stk.	
7	SW	Dug	1,276	16	6	Gravel	Hard	Dom. Stk.	Sufficient for 35 head
8	NE	Dug	1,217	12	-	Gravel	Hard	Dom. Stk.	
9	NE	Drl.	1,207	45	6	Sand	Hard	Dom. Stk.	
15	SW	Dug	1,210	8	6	Sand	Hard	Dom. Stk.	
16	SE	Dug	1,207	10	6	Sand	Hard	Dom. Stk.	
18	SW	Drl.	1,274	48	45	Sand	Hard	Dom. Stk.	Sufficient for 20 head
20	NE	Dug	1,193	20	18	Sand	Hard	Dom. Stk.	Yields about 30 gallons a day
21	NW	Dug	1,222	24	19	Sand	Hard	Dom. Stk.	
22	SW	Dug	1,183	26	23	Till	Hard	Not.	Alkali water
22	NW	Dug	1,195	25	15	Drift	Hard	Dom. Stk.	
23	NE	Dug	1,225	40	25	Sand	Hard	Dom. Stk.	Sufficient for 50 head
24	SW	Dug	1,225	10	-	Sand	Hard	Dom. Stk.	Sufficient for 60 head
25	SW	Dug	1,223	12	8	Gravel	Hard	Stk.	Not sufficient
25	SE	Dug	1,240	18	12	Sand	Hard	Dom. Stk.	Sufficient for 15 head
26	SW	Dug	1,206	23	8	Till	Hard	Stk.	Not sufficient
28	NE	Dug	1,244	31	12	Gravel	Hard	Dom. Stk.	
28	SW	Dug	1,209	40	18	Sand	Hard	Dom. Stk.	
29	SW	Dug	1,188	33	30	Till	Hard	Dom. Stk.	
32	SE	Dug	1,291	20	17	Gravel	Hard	Dom. Stk.	
33	SE	Drl.	1,297	60	20	Gravel	Hard	Dom. Stk.	
34	SE	Drl.	1,268	38	-	Gravel	Hard	Dom. Stk.	Three dug wells
36	NW	Dug	1,230	14	9	Gravel	Hard	Dom. Stk.	Sufficient for 30 head
36	NE	Dug	1,237	18	14	Gravel	Hard	Dom. Stk.	Sufficient for 30 head

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 10, Range 19

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of Water	Use	Remarks
1	SW	Brd.	1,307	22	18	Sand	Hard	Dom.	
1	NE	Dug	1,279	14	10	Sand	Hard	Dom. Stk.	
1	NW	Dug	1,286	20	15	Drift	Hard	Dom. Stk.	
2	SE	Brd.	1,305	40	28	Till	Hard	Dom. Stk.	Sufficient for 10 head
2	SW	Dug	1,287	10	8	Gravel	Hard	Dom. Stk.	
2	NW	Dug	1,305	18	13	Gravel	Hard	Dom. Stk.	
3	NE	Drl.	1,313	60	20	Sand	Hard	Dom. Stk.	
4	SE	Drl.	1,331	75	-	Drift	Hard	Dom. Stk.	
4	NE	Dug	1,304	24	21	Sand	Hard	Dom. Stk.	Sufficient for 30 head
5	SW	Dug	1,338	23	18	Gravel	Hard	Dom. Stk.	Sufficient for 40 head
5	SE	Drl.	1,326	90	-	Sand	Hard	Dom. Stk.	Sufficient for 60 head
5	NE	Dug	1,285	14	10	Sand	Hard	Dom. Stk.	Sufficient for 50 head
6	SE	Drl.	1,351	60	-	Drift	Hard	Dom. Stk.	Sufficient for 40 head
7	NE	Dug	1,329	22	20	Sand	Hard	Dom. Stk.	
7	SE	Dug	1,303	15	-	Sand	Hard	Dom. Stk.	
7	NW	Dug	1,318	28	21	Sand	Hard	Dom. Stk.	
8	SE	Dug	1,333	30	22	Sand	Hard	Dom. Stk.	
9	NE	Dug	1,313	22	18	Sand	Hard	Dom.	
10	SW	Dug	1,327	22	15	Gravel	Hard	Dom. Stk.	
12	NW	Dug	1,348	16	8	Sand	Hard	Dom. Stk.	Sufficient for 75 head
15	SW	Dug	1,302	50	31	Till	Hard	Dom. Stk.	
17	NE	Dug	1,304	28	19	Drift	Hard	Dom. Stk.	
18	NW	Dug	1,299	25	20	Gravel	Hard	Stk.	Not sufficient
20	SW	Dug	1,279	14	10	Gravel	Hard	Dom. Stk.	
29	NE	Dug	1,185	25	8	Gravel	Hard	Dom. Stk.	
30	NW	Dug	1,173	16	10	Gravel	Hard	Dom. Stk.	
30	NE	Dug	1,230	10	6	Gravel	Hard	Dom. Stk.	
31	NE	Dug	1,322	20	-	Sand	Hard	Dom. Stk.	
34	NE	Dug	1,325	16	12	Sand	Hard	Dom. Stk.	
34	NW	Dug	1,322	16	12	Sand	Hard	Dom. Stk.	

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 10, Range 20

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of Water	Use	Remarks
1	NW	Dug	1,366	27	20	Drift	Hard	Dom. Stk.	Sufficient for 20 head
2	SW	Dug	1,361	20	15	Sand	Hard	Dom. Stk.	Sufficient for 80 head
2	NE	Dug	1,367	29	22	Drift	Hard	Dom.	
3	SE	Dug	1,365	22	12	Sand	Hard	Dom. Stk.	Sufficient for 60 head
4	SE	Dug	1,366	22	16	Sand	Hard	Dom. Stk.	Not sufficient
4	NW	Dug	1,395	20	15	Drift	Hard	Dom.	
5	NW	Dug	1,394	24	12	Sand	Hard	Dom. Stk.	
7	NE	Dug	1,401	20	18	Sand	Hard	Dom. Stk.	Sufficient for 10 head
8	SE	Dug	1,379	24	19	Sand	Hard	Dom. Stk.	
9	NW	Dug	1,385	15	11	Sand	Hard	Dom. Stk.	
10	NE	Dug	1,361	22	19	Sand	Hard	Dom. Stk.	Sufficient for 30 head
12	NW	Dug	1,348	61	30	Sand	Hard	Dom. Stk.	
13	SW	Dug	1,338	27	21	Drift	Hard	Dom. Stk.	
14	SE	Dug	1,343	76	20	Drift	Hard	Not.	
14	NE	Dug	1,335	45	30	Drift	Hard	Stk.	
15	NW	Dug	1,357	30	20	Till	Hard	Dom. Stk.	
16	NE	Dug	1,375	28	-	Till	Hard	Dom. Stk.	Dry in winter months
17	NE	Dug	1,378	35	30	Sand	Hard	Dom. Stk.	
19	NW	Drl.	1,393	85	70	Sand	Hard	Dom. Stk.	
19	SW	Dug	1,391	40	27	Drift	Hard	Dom. Stk.	
20	NW	Drl.	1,416	80	-	Drift	Hard	Dom. Stk.	Sufficient for 50 head
20	SE	Drl.	1,387	60	-	Drift	Hard	Dom. Stk.	
22	SW	Brd.	1,340	40	20	Till	Hard	Stk.	
25	NW	Dug	1,264	20	-	Till	Hard	Dom.	
26	NE	Dug	1,187	20	5	Sand	Hard	Dom. Stk.	Sufficient for 75 head
30	NE	Drl.	1,386	80	60	Sand	Hard	Not.	
34	NE	Dug	1,223	45	-	Till	Hard	Not.	
36	SW	Dug	1,353	29	13	Sand	Hard	Dom. Stk.	Sufficient for 60 head

REPRESENTATIVE WELL RECORDS, BRANDON-SOURIS AREA, MANITOBA
Township 10, Range 21

Sec.	¼	Type of Well	Elev. (feet)	Depth (feet)	Depth to water (feet)	Aquifer	Quality of Water	Use	Remarks
3	NW	Dug	1,417	18	10	Sand	Hard	Dom. Stk.	Sufficient for 50 head
3	SW	Dug	1,420	16	13	Sand	Hard	Dom. Stk.	
4	SE	Dug	1,400	18	6	Drift	Hard	Dom. Stk.	
9	SW	Dug	1,399	6	3	Sand	Hard	Dom. Stk.	
10	NW	Dug	1,400	20	12	Gravel	Hard	Dom. Stk.	Sufficient for 45 head
10	SE	Dug	1,409	40	8	Sand	Hard	Dom. Stk.	
12	NW	Dug	1,416	20	5	Sand	Hard	Dom. Stk.	
13	SE	Dug	1,407	12	8	Sand	Hard	Dom. Stk.	
16	SW	Dug	1,412	12	8	Sand	Hard	Dom. Stk.	
16	NE	Dug	1,430	27	22	Sand	Hard	Dom. Stk.	
17	NW	Dug	1,404	16	9	Sand	Hard	Dom. Stk.	Sufficient for 30 head
17	SE	Dug	1,397	7	4	Sand	Hard	Dom. Stk.	
18	NE	Dug	1,459	60	58	Sand	Hard	Dom.	Stock well 14 feet deep
18	SW	Dug	1,412	14	7	Sand	Hard	Stk.	
19	SE	Dug	1,460	55	51	Sand	Hard	Dom. Stk.	Sufficient for 18 head
20	NE	Dug	1,461	52	47	Sand	Hard	Dom. Stk.	
21	SW	Dug	1,470	70	62	Sand	Hard	Dom. Stk.	
22	SW	Dug	1,457	50	47	Drift	Hard	Dom. Stk.	Sufficient for 30 head
23	SW	Dug	1,449	50	40	Sand	Hard	Dom. Stk.	Sufficient for 30 head
24	SW	Dug	1,425	19	16	Sand	Hard	Dom. Stk.	
24	NE	Dug	1,428	40	32	Gravel	Hard	Dom. Stk.	Sufficient for 30 head
27	NW	Drl.	1,426	44	24		Hard	Dom. Stk.	
28	SE	Dug	1,437	14	11	Sand	Hard	Dom. Stk.	Sufficient for 50 head
28	SW	Dug	1,433	40	12	Drift	Hard	Not.	
29	NE	Dug	1,417	16	13	Sand	Hard	Stk.	Sufficient for 50 head
29	SW	Dug	1,456	48	41	Sand	Hard	Stk.	Sufficient for 30 head
30	SW	Dug	1,383	42	31	Till	Hard	Dom. Stk.	
31	SE	Dug	1,347	25	23	Till	Hard	Stk.	
32	SE	Dug	1,408	14	10	Till	Hard	Dom.	
32	NE	Dug	1,367	14	8	Sand	Hard	Dom. Stk.	Sufficient for 50 head

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CHAPTER I

INTRODUCTION

This report deals with ground-water conditions of Langley municipality in the province of British Columbia investigated by the Geological Survey of Canada during the field seasons of 1954 and 1955. Geological mapping of the area was carried out under the direction of J.E. Armstrong, who has supplied Chapter II of this report. The writer supervised the ground-water investigation and collected much of the water data. Others whose assistance in the field is acknowledged were: in 1954, G. Rayner; in 1955, J. Stothers and P. Strack. The writer wishes to thank all well owners and drillers for their cooperation and willingness to supply information.

Ground-water surveys in this area provide basic information necessary for the future development of domestic, irrigational, industrial and municipal ground-water supplies. This survey has shown that gravel and sand aquifers deposited as outwash plains at or near the surface will yield large supplies of free ground water. Confined artesian water is available in aquifers of sand and gravel within 300 feet of the land surface in the upland areas, whereas, flowing artesian water is available in the Langley Lowland where wells are drilled from 50 to more than 900 feet.

METHODS OF INVESTIGATION

The investigation included the collection of data on more than 1,000 wells in the area. These records vary greatly in accuracy as in most cases no drilling data were recorded and the information obtained was based mainly on the memories of well owners and well drillers. The most accurate information was gained from wells being drilled at the time of the survey, as such wells were observed during the course of the work and pertinent data obtained. Later studies showed that, on the basis of known geology, the information obtained on about 250 wells could be interpreted with accuracy, and only these data are included in this report and plotted on the accompanying map. Information regarding other wells may be obtained

from the Geological Survey office, Vancouver, B.C.

LOCATION AND EXTENT OF AREA

Langley municipality lies within the Fraser Lowland and extends from the Canada-United States boundary (700 feet north of the 49th Parallel) for a maximum of 13 miles, to latitude 49°13'N. The eastern boundary follows a meridian a few seconds east of 122°28'W and the western boundary of the municipality follows a meridian a few seconds east of 122°41'W. The area of the municipality is about 122 square miles.

CLIMATE

The mountains north and east of Fraser Lowland are the most important factor that influences the climate of this area. Annual precipitation at the foot of the Pacific Ranges is 80 inches whereas on the Fraser Delta it averages 35 inches. Heavy winter rainfall and a summer dry period are characteristic. About 70 per cent of the precipitation occurs during the period October to March. Even in the wet years the growing season, from April to September, has too little precipitation for the maximum development and yield of crops.

Within Fraser Lowland summer rainfall is highly variable and unpredictable. July is the driest month and generally drought conditions prevail one year out of every five or six. During drought conditions experienced in 1951 and 1952, crop production in Langley municipality was markedly affected. This led to an increased interest in irrigation, and particularly in the use of ground water for this purpose.

The rainfall patterns indicate that annual replenishing of the ground-water reservoirs is readily obtained. The heavy sustained rains from October to March allow a long period for infiltration and keep the soil and sediments above the water-table continually wet. The heavy rains also come in the season when vegetation requires little water, and at a time of the year when humidity is high and evaporation low. These considerations show that apart from run-off, which is appreciable in the upland areas, a large proportion of this winter rainfall infiltrates into the soil and becomes a

part of the body of ground water beneath the municipality.

AGRICULTURE[1]

The type of agriculture throughout the Fraser Lowland is dependent upon local drainage, climate, availability of ground water or surface water for irrigation, soil type and natural vegetation. The requirements for the Vancouver market, which is the main buyer of the Lowland's produce, also determine to some extent what is grown.

The black soils attracted much attention and farming began shortly after Fort Langley was established as a trading post in 1827. Dairying, mixed farming, market gardening and the growing of small fruits are the main types of agriculture. Small fruit production, centred in Fraser Lowland, amounts to 85 per cent of the total provincial fruit production. The raising of chickens and turkeys is carried on extensively in the upland areas.

In Langley Lowland dairying has been the main type of agriculture. An ample supply of flowing artesian water is available. By 1914 some 270 flowing wells had been drilled in the Surrey and Langley districts. A total of 450,492 gallons a day was estimated as being discharged from 101 of these wells whereas the total requirements of the 74 interests dependent on this water amounted to approximately 50,000 gallons a day[2].

POPULATION

According to a census taken in 1955, the population of Langley municipality is 11,194 and that of Langley city is 2,022.

TOPOGRAPHY AND DRAINAGE

Langley municipality forms a part of Fraser Lowland of southwestern

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1 Kelly, C.C., and Spilsbury, R.H.: Soil Survey of the Lower Fraser Valley; Dept. of Agriculture, Canada, Pub. 650, pp. 14, 15 (1939).

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2 Province of British Columbia, Report of Water Rights Branch of the Department of Lands, for the year ending December 31st, 1914, p. 19.

British Columbia, which in turn forms a part of the Georgia Depression. Fraser River, along the north boundary of the municipality, occupies a post-glacial valley up to 3 miles wide and 50 feet or more deep. This river has a length of 790 miles from its source in Yellowhead Pass, and drains an area of 91,700 square miles. It terminates in a delta that is 19 miles long and 15 miles wide and still growing.

Langley Lowland, a former embayment of the sea, separates the two major upland areas of the municipality. The floor of this lowland is relatively flat and is drained south from Milner by Nicomekl River and north from Jardine Station by Salmon River. The elevation of the lowland in its broad centre part is about 25 feet above sea-level but arches slightly to attain elevations of more than 50 feet between Milner and Jardine Station. North of Jardine Station the lowland narrows, has considerably more relief and joins a former meander channel of Fraser River that presents a flat semi-circular area about 1 mile wide surrounding an upland of about one square mile, on which Fort Langley is built.

Clayton Upland in the northeast quarter of the municipality trends northeast and is bordered on the south and east by Langley Lowland and on the north and west by a lowland area extending to Fraser River. Clayton Upland is a rolling hilly surface 200 to 300 feet above sea-level. This upland is nearly ellipsoidal in shape and lies partly in Surrey Municipality. Run-off from this upland collects in rivulets and short streams that cut deep narrow channels into the surface and drain north to Fraser River. The slopes bordering Langley Lowland are abrupt and have been modified by wave-cutting and later slope wash.

Langley Upland occupies the east and south part of the municipality. It is bounded on the north by Glen Valley and Fraser River, on the north and west by Langley Lowland and on the southwest by Campbell Upland. The surface is hilly and in places reaches elevations of more than 400 feet above sea-level. Run-off over this hilly surface is drained to the south by Bertrand Creek, to the west by Campbell River and along Langley Lowland by tributaries of Nicomekl and Salmon Rivers. An area of about

4 square miles north of Trans-Canada Highway and bounded by Livingstone and Otter roads has a flat surface which drops off abruptly on the west side and is cut by a tributary of Salmon River.

Campbell Upland, an area of about 11 square miles, is partly in Surrey municipality. It has a flat-topped terraced surface 125 to 150 feet above sea-level. Campbell Creek crosses the north part of this upland.

Glen Valley in the northeast corner of the municipality has a flat floor 20 feet above sea-level from which slopes rise abruptly to elevations of more than 350 feet. Part of Glen Valley is in Matsqui municipality. This valley represents a meander channel of an earlier stage of Fraser River that has been cut off by lowering of the present channel or an embayment cut by water of Stave River at its entrance with the Fraser. Short creeks originating in the upland areas south and east of Glen Valley have cut narrow valleys through the steep slopes and spill out in natural or man-made drainage channels across the floor of the valley.

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CHAPTER II

PLEISTOCENE AND RECENT GEOLOGY [1]

TYPES OF DEPOSITS

The entire municipality of Langley is underlain by thick deposits of unconsolidated sediments of Pleistocene and Recent ages. The term Pleistocene refers to that epoch in the earth's geological history when large areas of the earth's surface were periodically covered by great glaciers many thousands of feet thick. The epoch is estimated to have started about one million years ago and to have continued in the Langley area to within five to eight thousand years of the present. The term Recent has been used to refer to post-glacial time.

The deposits formed during the Pleistocene and Recent periods are shown on the table of surficial deposits accompanying this report. They consist of clay, silt, sand, gravel, peat, varved clay and silt; stony, clayey silt, silty clay and related till-like mixtures; and till. The terms clay, silt, and sand as used in this report are based on the diameter of the constituent particles and are used as follows: clay, less than 0.002 mm.; silt, 0.002 to 0.05 mm.; and sand, 0.05 to 2 mm.

The clays and silts are composed chiefly of rock flour produced by mechanical abrasion by glaciers and only to a very minor extent of clay minerals formed by chemical decomposition of rocks. The sands are in a large part quartz but contain in addition many feldspar and rock fragments. The clays and silts and mixtures of the two are mainly off-shore marine deposits, and to a much lesser extent stream and river deposits, both flood plain and channel. The sands and also the gravels may be outwash, (glacio-fluvial) beach, or stream and river deposits. Outwash consists of the sediments deposited by streams issuing from glaciers. The peat represents swamp deposits. Varved clay and silt are glacial-lake deposits consisting of alternating light and dark coloured layers a fraction of an inch to several inches thick.

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[1] Chapter written by J.E. Armstrong

The stony, clayey silt, silty clay, and related till-like mixtures are in a large part glacio-marine and to a lesser extent normal marine deposits that were laid down in the sea during the advance and retreat of an ice-sheet and during the subsequent uplift of the land. The glacio-marine deposits are marine drift; that is, the stones and part of the fine material were transported by floating ice and the remainder of the fine material was carried by meltwater and sea water. The somewhat similar deposits of normal marine origin are mainly reworked till and reworked marine drift resulting from submarine erosion as the land rose above the sea. Mechanical analyses of stony, clayey silts and silty clays, show that, exclusive of stones, they comprise about 40 per cent silt, 40 per cent sand, and 20 per cent clay.

Glacial till, as used in this report, is a very compact unsorted mixture of sand, silt, clay, and stones deposited directly beneath glacial ice. The only tills exposed in Langley municipality are the Sumas and Surrey, of the older tills only Semiamu has been identified in well records. Mechanical analyses of the fine fraction of representative samples of tills from the 'Lower Mainland' yielded the following average results: Sumas till, 63 per cent sand, 33 per cent silt, and 4 per cent clay; Surrey till, 57 per cent sand, 41 per cent silt, and 2 per cent clay; and Semiamu till, 47 per cent sand, 45 per cent silt, and 8 per cent clay.

The unconsolidated sediments in Langley municipality attain a maximum thickness of at least 1,000 feet and in places may be much thicker; for example, the Cloverdale sediments alone are more than 900 feet thick in the Milner area.

STRATIGRAPHY AND HISTORICAL GEOLOGY OF PLEISTOCENE AND RECENT DEPOSITS

The table of surficial deposits that accompanies this report shows graphically the complex interrelations and age of the surficial materials. The oldest deposits are shown at the bottom of the table and the youngest at the top. Deposits shown along side one another indicate that they are of the same general age but were laid down in different environments. Note that the graphic representation illustrates, for example, that Sumas glacial

deposits were laid down in part of the area at the same time non-glacial Capilano deposits were laid down elsewhere in the area. A hole drilled in search of water would penetrate the deposits in the order shown from the top of the table to the bottom except where a deposit has been removed by erosion or locally was not deposited.

All ages are relative except in the case of the Capilano and Quadra deposits, where radio-carbon age determinations have been made on wood collected from them outside the map-area. Wood from the base of Sumas till, and hence a part of the Capilano group, was dated as 11,300±300 years old. Wood from the Quadra group inter-till sediments was dated as older than 30,000 years.

Study of the table of surficial deposits indicates that the area was subjected to four glaciations: three probably major, namely, Seymour, Semiamu, and Vashon; and one, Sumas, probably valley glaciation only. The Seymour and Vashon glaciations reached ice-sheet proportions during their maxima at which time they were probably 7,500 feet or more thick over the valleys. At these times the ice moved in a general southerly direction; that is, off the Coast Mountains. The Semiamu ice was probably also of ice-sheet proportion, but due to later erosion, deposits of this group are so poorly preserved that a reliable history of this ice advance cannot be pieced together. Post-Vashon Sumas valley ice advanced into the northeastern part of Langley municipality and recessional Abbotsford outwash related to this ice advanced westward across the municipality.

During each major glaciation the land was depressed relative to the sea, and this lowering of the land surface amounted to at least 1,000 feet in the case of Vashon glaciation. At the maximum of Vashon glaciation the ice rested on the sea floor. Maryhill outwash was deposited in advance of the ice and Surrey till beneath the ice. During the retreat of Vashon ice, largely by wasting, the ice thinned and floated and glacio-marine Newton stony clay deposits were laid down. After the Vashon ice melted and as the land rose above the sea, the off-shore marine Cloverdale sediments and the marine-shore Sunnyside sand and Bose gravel deposits were

laid down.

During post-Vashon time the Sumas valley ice advanced westward into Langley municipality. In its initial advance stages this ice-sheet terminated in the sea and deposited glacio-marine Whatcom deposits in front of and beneath the ice. At the same time normal marine deposits were laid down in the sea west of the Sumas ice-sheet. As the land rose the Sumas glacier was grounded and advanced and retreated across the Whatcom glacio-marine drift depositing Sumas till and recessional Abottsford outwash.

Up to the end of 1955 a total of about 45 species of marine fossil shells had been collected and identified from Newton stony clay. Whatcom glacio-marine, Cloverdale sediments, Sunnyside sand, and Bose gravel deposits. They were collected from more than 50 localities within the Fraser Lowland ranging from 5 to 575 feet above sea-level. Marine shells similar to these assemblages are now found in the sea in latitudes ranging from 60° to 63° North; that is, 760 to 950 miles north of Langley.

As shown in the table of surficial deposits, one probable interglacial period, the Quadra, has been recognized between the Seymour and Semiamu ice-sheets. Apparently climatic conditions existing at that time were somewhat similar to those at present as is indicated by a study of the pollen and plants from the peat of the Point Grey beds.

Huntingdon gravel deposits underlie Whatcom glacio-marine deposits. They appear to be stream deposits that were laid down following the retreat of Vashon ice but before the advance of Sumas ice. West of Langley municipality the deposition of similar gravel probably continued throughout Capilano time.

Two major erosion intervals are shown on the table of surficial deposits, one separating the Semiamu from the Quadra group below and the other separating the Semiamu from the Vashon group above. The hills in the Fraser Lowland were shaped during the latter erosion interval and were mantled by Vashon group deposits. Surrey till conforms to the slopes of the hills truncating underlying older deposits.

The Salish deposits, which are still in the process of formation,

consist of channel and flood plain deposits of the Fraser River and smaller streams, and peat bogs.

DISTRIBUTION OF PLEISTOCENE AND RECENT DEPOSITS

The distribution of the Sumas and younger deposits is fairly obvious from a study of the geological map accompanying this paper. The Salish and the non-glacial Capilano deposits, except for Bose gravel and Sunnyside sand, are confined to the lowlands.

Pre-Seymour and Seymour deposits are not exposed in the area, but several wildcat holes drilled in a search for oil and gas and a few of the deeper drilled water wells intersect unconsolidated and semi-consolidated sediments believed to be correlative to Seymour and older.

Quadra sediments, mainly Nicomekl silt deposits, are exposed on the lower slopes of Clayton Upland. Many of the drilled wells in this upland intersect similar sediments. Semiamu deposits are not exposed in the municipality but have been positively identified in the deep well drilled by the Royal Canadian Navy near Aldergrove, and have been tentatively identified in other holes.

Exposures of Surrey till are found only in the western part of the municipality, however this till is widespread beneath Newton and Whatcom glacio-marine deposits throughout Langley. Newton stony clay deposits appear at the surface in most of Clayton Upland, elsewhere they underlie lithologically similar Whatcom deposits and, except where separated by Huntingdon gravel, the contact between the two is in many places arbitrarily drawn. Also the surface mapping of the Newton and Whatcom has been done partly on a geographic basis; west of the Langley-Milner valley has been shown as Newton and east as Whatcom; whereas locally evidence may be lacking to support this mapping.

Huntingdon gravel deposits outcrop only in a few scattered areas, but are widespread beneath Whatcom deposits.

CHAPTER III

GROUND-WATER GEOLOGY

GENERAL CONDITIONS

Ground water or underground water is the water that supplies springs and wells. Where surface water is lacking, contaminated or not in sufficient supply, man has dug wells in search of ground-water supplies. The presence and development of ground water, especially in arid or semi-arid regions, have determined the growth or absence of civilization.

The water stored in ground-water reservoirs is replenished during wet seasons and hence is a renewable resource. In many places ground water in sufficient quantity can be found to meet the demands of agriculture and industry without constructing large, long pipelines or aqueducts to carry water into an area from distant surface sources. The amount of water replenished annually and the amount available in storage in the ground-water reservoirs are important factors to be considered before undertaking programs of ground-water development.

Source

The source of all ground water is the precipitation that falls on the immediate or adjacent area, but only part of the water falling on an area will penetrate to the ground-water reservoirs. Part flows off the surface and part is held in the soil to be used by the plants and vegetation. An accurate estimate of the amount of rainfall that penetrates to the underground storage in Langley municipality, is considered beyond the scope of this report. However, an inch of rainfall on 1 square mile is equivalent to approximately 14,520,000 imperial gallons and in Langley municipality the average rainfall is 40 inches a year. If, say, 15 per cent of this rainfall is contributed to ground-water storage then 87,120,000 gallons[1] per square mile would be available annually for ground-water recharge.

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[1] "Gallons" in this report refers to "imperial gallons".

Occurrence

Pores and open spaces in both consolidated and unconsolidated rocks provide the openings through which ground water moves. Therefore, the size, shape and relation of these openings to one another control the quantity of water that the rock can hold and also the ease or ability with which the rock gives up the water. If the openings or pore spaces are large and interconnected, as they commonly are in sand and gravel, the water is transmitted freely and the rock is said to be permeable. Where the pore spaces are very small, as in clay, the water is transmitted very slowly or not at all and the rock is said to be impermeable. Furthermore, a deposit of uniformly sized, well rounded material may be more porous and permeable than a variously sized material because in the latter the smaller particles occupy the interstices between the larger ones.

In rocks that are saturated all the pore spaces are filled with water. This condition exists in clay as well as in sand and gravel, but the pore spaces in sand and gravel are larger and hence the rock is more permeable, therefore successful wells are more likely to be developed in the coarser materials. The difference in permeability between two rocks, such as sand and clay, allows for seeps and springs. Water percolating through porous sand upon encountering a layer of clay cannot move as readily through it because the pore spaces are minute. The water moves along the top of the clay layer and issues as springs or seeps where the top of the clay layer is exposed along hillsides or road-cuts.

Water-Table and Movement of Ground Water

Rain falling on an area of sand and gravel percolates downward through the pore spaces between the grains composing the sand and gravel. The downward percolation by the force of gravity continues until a zone is reached in which all the pore spaces are filled. This zone is the zone of saturation and its upper surface is the water-table. In Langley municipality this condition exists in two areas, one the Campbell Upland and the other an area of Abbotsford outwash in the central part of Langley Upland. Both areas constitute a free ground-water reservoir.

Elsewhere the ground water is confined below relatively impervious layers such as glacial till and glacio-marine clays. The water in such aquifers known as confined ground-water reservoirs is under pressure such that when the strata are penetrated by a well, water rises in the casing. The surface to which the confined water rises is the pressure or piezometric surface. In the lowland areas the water is commonly under sufficient pressure to rise to a point above the ground surface and flow, whereas in other areas the pressure is sufficient only to raise the water to a point above the aquifer.

It is evident then that no continuous over-all free water-table exists under Langley municipality. A continuous water-table exists in areas of free ground water but elsewhere the ground water rises to a pressure surface that does not coincide with the free ground-water tables.

Water penetrating the soil zones or entering from streams penetrates downward to a saturated zone where there is lateral movement from areas of recharge to lower areas of natural discharge. The rate of movement may be in the order of only a few inches a year in the marine clays and a foot or more a day in uniform sands.

Fluctuations of the water-table are in response to the amount of water that is either added to or subtracted from the ground-water reservoir. In Langley municipality lowering of the water-table is due to subsurface drainage to adjoining areas or to overdraft by excessive pumping. The water-table is raised by additions to the reservoir either from rainfall or seepage water from adjacent areas. If a well does not penetrate the lowest level of the water-table it can be expected to go dry.

The pressure surface is lowered in the lowland areas by too many wells flowing freely. This is evident where wells have been drilled nearby a former flowing well and, after drilling, the original well ceases to flow.

Recharge

Water that penetrates to the saturated zone and is added to the

ground-water reservoirs is recharge. Recharge is dependent upon precipitation and its distribution throughout the year. Rain falling in the growing season will contribute little or nothing to the recharging of an aquifer as the water is lost in evaporation, run-off, or used by plants. The precipitation as rain or snow during periods of dormant growth provides the maximum recharge. Rising water-tables can be expected during February and March as a result of heavy rainfall during the months of October and November. However, where the rate of downward penetration and lateral movement of the recharge water is reduced by material of low permeability no rise in the water-table or static level in a well may be noticeable until the summer months.

Aquifers in Langley municipality are also recharged by infiltration from aquifers in the highlands east of the municipality. It is also suggested that the Langley Lowland receives recharge from waters of Fraser River that infiltrates through gravel and sand along the bed of the river.

Discharge

Ground water is discharged by springs, subsurface flow, evaporation and transpiration. Ground water is discharged by springs in Langley municipality along the boundaries of outwash areas and at the edge of the uplands. Discharge by underground outflow is probably balanced by that quantity flowing in by underground replenishment. The loss of ground water by evaporation from the surface soil and the loss through the transpiration of plants where the water-table is near the surface is probably a minor amount under the climatic conditions characteristic of the Fraser Lowland.

Artificial discharge takes place through wells and considerable ground water is wasted in the Langley Lowland where at least 200 artesian wells discharge on the average 500 gallons an hour each or 2,400,000 gallons a day. The rate of flow of these wells could be lessened by installing higher standpipes on the wells thus reducing the overflow; however, this procedure also reduces the pressure at the outlet. The installation of valves on these wells would reduce the flow but there is also risk of

someone closing the valve and upon reopening, pressure built up is released and fine sands are pulled into the well plugging the casing.

GROUND-WATER RESERVOIRS

Two main types of ground-water reservoirs are present in Langley municipality, namely, free ground-water reservoirs and confined ground-water reservoirs. Both types may be perched in that they are separated from the main body of ground water by nearly impervious sediments such as clay, stony clay or till. In this report the term ground-water reservoir is used interchangeably with the term aquifer. An aquifer includes not only individual water-bearing beds a few feet thick but also a thick series of beds of varying permeability where the individual beds are more or less interconnected hydraulically.

Free Ground-Water Reservoirs

The glacio-fluvial deposits mapped as Abbotsford outwash (9)[1] which cover 10,000 acres or more, range in depth from 5 to more than 100 feet and constitute areas of free ground-water reservoirs. Water falling on the surface of such an area penetrates downward by gravity and occupies the interstices between the grains of sand and gravel. The water is not confined but moves under the influence of water-table slopes. If the sand and gravel are underlain by impervious or nearly impervious sediments the free ground-water reservoir is perched. The static level of the water in wells penetrating free ground-water reservoirs whether perched or not is the water-table and such wells are non-artesian water-table wells.

Newton (3) and Whatcom (7) glacio-marine stony clayey silts and silty clay that mantle the upland areas are nearly impervious but capable of passing small quantities of water, especially where they contain small lenses of coarser material. These glacio-marine deposits constitute a perched free ground-water reservoir of limited storage capacity and shallow wells dug in them will yield a limited supply of water commonly

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1 Numbers in brackets are those of map-units on the accompanying geological maps.

not sufficient for domestic use. These wells act as natural cisterns that fill during the rainy season and if placed to take advantage of local slopes, catch natural drainage during dry periods.

Confined Ground-Water Reservoirs

The water in confined ground-water reservoirs does not move under the influence of water-table slopes but is confined by an overlying impervious stratum and, hence, movement is restricted vertically but not necessarily horizontally. The Cloverdale sediments (4) of the Langley Lowland are in places as much as 900 feet thick and consist of lenses of coarser units within the clay and silt. These lenses represent confined ground-water reservoirs that may be interconnected or separate and the water that they contain is under pressure and rises to the surface to flow where such lenses are penetrated by wells.

In the upland areas ground-water reservoirs of Huntingdon gravel (5) and pre-Vashon deposits (1) are confined below the nearly impervious Whatcom (7) and Newton (3) deposits and Surrey till (2). The water in these reservoirs is under pressure sufficient to raise it above the top of the confined reservoir but not sufficient to raise it to the land surface to flow as a flowing artesian well. The recharge area to the confined reservoirs may not be adequate and the initial yield may give an erroneous impression that an abundant perennial supply is available. However, in most places the sand and gravel between the stony clays are thick enough to constitute confined ground-water reservoirs capable of supplying water in the order of 5 to 20 gallons a minute.

CHAPTER IV

TYPES OF WELLS AND WELL DEVELOPMENT

The trend in modern well drilling is towards the development of wells. Therefore, this section is added to draw the attention of engineers, drillers, and prospective well owners in Langley municipality to certain fundamental principles of ground-water recovery and well use so that they may know the problems that exist and corrective measures that are being employed elsewhere. Additional information may be obtained from drillers' magazines and from some of the references listed on page 5 of this report.

A well is constructed to tap the ground-water reservoirs and obtain therefrom, as economically as possible, the required amount of ground water. Failure to obtain water is due either to conditions existing in the formations penetrated or to the type of well and construction methods used.

TYPES OF WELLS

Dug, bored, driven and drilled wells are the four main types and each has its special use and function under existing conditions. The factors that determine the type of well are: depth to water, characteristics of the sediments from ground surface to the water, characteristics of the water-bearing sediments, the static level of the ground water, the amount of water required and the investment that the prospective owner wishes to make.

Dug wells are of limited usefulness in Langley municipality because the depth to an abundant water supply normally exceeds 30 feet and over a large part of the municipality the ground water is under hydrostatic pressure beneath a confining impervious bed. Dug wells in the upland areas penetrate Newton (3) or Whatcom (7) stony clays, are easy to dig, but their yield fluctuates seasonally. Most of the water is collected from surface run-off and therefore these wells act chiefly as cisterns. Dug wells are effective on the lower slopes of the uplands near the spring line and in areas of extensive outwash.

Bored wells, sunk by means of a hand or power driven auger, are not widely used but where the stony clays are 50 feet or less thick

power driven bucket type augers could be used to penetrate to the underlying water-bearing sands. Bored wells that reach running sands or quicksand may yield enough water if sandpoints are driven into the bottom of them.

Driven wells are constructed by driving a casing tipped with a drive point or sandpoint. Although an advantage over a dug well, driven wells are limited in their use to areas of outwash where the sands are medium to coarse grained. Driving sandpoints through the marine clays on uplands to underlying sands is not recommended as stones are encountered in the clays. In Langley Lowland the Cloverdale sediments (4) are too fine to give up water contained in them to pumps attached to sandpoints, however sandpoints can be used in areas of Sunnyside sand (6).

Drilled wells are the most effective for development of ground water in a large part of Langley municipality. They may be finished as open-end, screened or gravel-packed wells, all of which are lined with a casing commonly 6 inches in diameter. Cable tool drilling rigs are used to drill such wells but in Langley Lowland where the water is present under pressure sufficient to cause it to rise to the surface and flow, wells are drilled by means of a jetting rig. In jetting a well, the casing less than 2 inches in diameter is forced down during the drilling as the sands and sediments are washed up by means of water forced through the drill stem. These wells are common in the lowland areas and penetrate depths of as much as 700 feet.

An open-end well allows water to enter through the open end of the casing. No screen or other device is used to keep sand from entering the well and hence failures are common especially when over-pumping is carried on. All wells drilled by the jetting method are open-end wells.

Screened wells are those in which some sort of a device such as a screen or strainer is used on the lower end of the casing to prevent the infiltration of fine sand into the well under pumping. Depending on the method of development used after installation of the screen or strainer, the well becomes either naturally gravel packed or gravel is added as a packing around the screen. By use of proper developing equipment, the

the fine material around the screen is removed through the screen. This development grades the material in the water-bearing formation in such a way that the greatest possible amount of open space is provided for the water to flow through. Where the water-bearing material is so fine and uniform in size that natural gravel packing is impossible, gravel may be introduced around the screen as a packing. Such wells are gravel treated wells, and where this treatment is anticipated the initial well is drilled with a larger diameter than the final well so that the gravel can be packed around the screen after the screen has been placed in position.

WELL DEVELOPMENT

Wells are developed by means of post-drilling treatments to establish the maximum rate of usable water yield. To improve the yield, the methods commonly used include surging, over-pumping, backwashing and treatment with acids, or other chemicals. All methods, except the acid treatment, are designed primarily to wash the fine sand, silt or clay from the water-bearing formation immediately surrounding the well screen.

Surging is the method most commonly used where the water-bearing materials contain sand and fine gravel mixed with silt but over-pumping is a satisfactory procedure where coarse sand and gravel make up the aquifer. The surging method involves the use of a surge plunger which is operated up and down in the well casing for the purpose of alternately creating an inward and outward movement of water through the screen. The repeated surging action eventually moves the fine sand up to and through the screen from where it is removed by bailing. After the fine particles have been drawn into the well and removed, the coarser particles left on the outside of the screen have created a new mixture of particles having a high porosity and permeability. The treatment known as backwashing includes operating the pump at its maximum capacity and periodically stopping the pumping and releasing the foot-check valve. The water then rushes back into the well and agitates the sediment around the screen.

A developed well provides the greatest possible amount of water from the water-bearing material into which the well is drilled. Therefore, wells are developed to increase their specific capacity or yield per foot of drawdown. During pumping the water in the well drops from its static level to the pumping level, and this drop measured in feet is known as the drawdown. As the water in the well drops to the pumping level, the attitude of the water level in the aquifer around the well becomes that of an inverted cone. The size and shape of this cone, known as the cone of depression is controlled by the rate of pumping, the permeability or water yielding capacity of the water-bearing material and the slope of the water-table in the vicinity of the well. For example, if the pumping rate is high and the water-bearing material is coarse, then the cone of depression will affect a large area of the water-table but the height of the inverted cone will be relatively small. Under these conditions many neighbouring wells may be affected. When the pumping is stopped the dewatered area normally fills up again.

The specific capacity or yield per foot of drawdown of a well should be determined especially when large flows are demanded. With the advent of the practice of irrigation to produce maximum crop yield it is necessary that wells drilled for this purpose be developed to maximum capacity as they will be subjected to long term pumping. Most wells drilled for domestic or farm needs do not require extensive development as the initial yield meets the water requirements.

CHAPTER V

GROUND-WATER GEOLOGY OF LANGLEY MUNICIPALITY

Ground water is obtained in Langley municipality from free or confined ground-water reservoirs. Free ground-water reservoirs, as shown on the accompanying map, are those areas where Abbotsford outwash (9) and Sunnyside sand (6) are at or near the surface. Wells that tap free ground-water reservoirs are non-artesian. Confined ground-water reservoirs supply water that is under pressure such that when the reservoir is penetrated by the drill the water rises in the well casing and in some cases flows at the surface. Huntingdon gravel (5), Cloverdale sediments (4) and pre-Vashon deposits of sand and gravel (1) are the principal confined ground-water reservoirs.

CAMPBELL UPLAND

Campbell Upland has an area of 10 square miles of which 7 square miles are in Langley municipality. It is underlain by Abbotsford outwash (9) which consists of permeable sand and gravel that constitutes the ground-water reservoir. The water-table conforms closely to the topography of the terraced upland and slopes about 25 feet to a mile but adjacent to Anderson Creek the slope steepens to 200 feet to the mile. The water-table may drop as much as 3 feet during periods of less than normal rainfall, such as that experienced during the summer of 1951, and will remain at this level until early winter.

The total thickness of the outwash on this upland is not known. In SW.¼ sec. 27, tp. 7, on the border of Langley and Surrey municipalities, a test hole penetrated 88 feet of outwash sand and gravel. The water level in this test hole remains at 16 feet below the surface of the ground but drops to as much as 19 feet during dry summer months. The well was test pumped at about 200 gallons per minute.

Ground-Water Recharge and Discharge

Campbell Upland is ideally suited for an infiltration area. The coarseness of the outwash and the flat topography of this upland suggest

that at least 60 per cent of the precipitation that falls upon this area will infiltrate to the water-table. If this is correct, about 3½ billion gallons will recharge this reservoir annually. Anderson and Campbell Creeks continue to flow during drought seasons and are fed by ground water.

Recovery of Ground Water

Non-artesian wells up to 50 feet deep are used to recover the ground water, and sandpoints have also been used. The level of the water in these wells is the water-table. Upon consideration of the permeability of the outwash gravel and the annual recharge to this upland, it is reasonable to expect that drilled wells could be developed to deliver in the order of 500 gallons a minute.

CLAYTON UPLAND

The principal ground-water reservoirs underlying this upland are confined and included in the pre-Vashon group of sands and gravels (1). Perched ground water is present in the Newton stony clay (3) that covers the upland. Newton stony clay is 50 to 225 feet thick and in its upper limits yields a limited amount of water to cistern-type wells dug into it. Seasonal fluctuations of the water-table in these wells is such that during the summer months the wells are commonly dry. Two wells, drilled in the central part of the upland to depths of 222 feet and 256 feet, have encountered sands and gravels underlying the Newton stony clay. These gravels and sand, perhaps Semiamu sediments, are water bearing and are known to yield as much as 80 gallons a minute to open-end wells.

The main aquifers of this upland underlie the Newton stony clay (3) and, where present, Surrey till (2). From information available the piezometric surface closely parallels the topographic surface and also suggests a connection existing within the main aquifer. Along the slopes of the upland and below elevations of 150 feet the surface of the water-table drops steeply, between 300 and 500 feet a mile, whereas on the upland the water-table, as defined by the static level in non-flowing artesian wells, slopes 25 to 30 feet a mile.

Ground-water Recharge and Discharge

The total infiltration surface for the whole area of the upland is in the order of 5 square miles. The average annual rainfall is 40 inches of which perhaps 10 per cent penetrates the stony marine clays to recharge the underlying sands and gravels. Water is held from direct run-off on the surface by beach deposits of Sunnyside sand (6) overlying the marine stony clays.

Natural discharge is in part by springs and it is believed that these upland areas also discharge water from their main aquifers to the artesian aquifers underlying surrounding lowlands.

Recovery of Ground Water

Ground water is recovered by numerous dug wells and a limited number of deeper drilled wells. The dug wells rarely penetrate Newton stony clay (3) and are unsatisfactory in that the ground water supply is either lacking or dangerously low during the summer months.

The records of the following wells indicate that large quantities of ground water are available from aquifers underlying the marine stony clays and Surrey till (2). A well in SW.¼ sec. 22, tp. 8 penetrated 100 feet of marine clay and continued through 122 feet of pre-Vashon sand (1) and thin layers of silt and clay. Coarser sand and gravel was encountered at 222 feet and water in these gravels rose 64 feet in the casing. The well was test pumped for 9 days at 80 gallons a minute and the drawdown during pumping did not exceed 10 feet. In NE.¼ sec. 22, tp.8 a well penetrated 80 feet of relatively impervious clay and continued 100 feet through pre-Vashon sand and silt. At 180 feet an aquifer was encountered in which non-flowing artesian water rose 80 feet in the casing. This supply has been sufficient for the stock and domestic needs of the farm but no record of a pumping test is available. At Willoughby school, NE.¼ sec. 23, tp.8, an 8-inch diameter drilled well penetrated 225 feet of stony clay and 32 feet of sand that graded from fine to coarse at depth. The coarser sands are water bearing and the water rose 80 feet in the casing.

Other drilled wells have not been successful and their failure was due to either not being drilled deep enough, that is drilling operations were ceased before penetrating the stony clay, or to encountering fine sands that presented a problem in the well development which could not be solved by the drillers employed.

LANGLEY UPLAND

One free and at least two confined ground-water reservoirs exist within the Langley Upland. Free ground water is present in an area of about 10 square miles lying in the central part of Langley Upland north of Trans-Canada Highway. This is an area of Abbotsford outwash (9) that averages 5 to 10 feet in thickness along its eastern edge and thickens to as much as 80 feet along the western edge adjacent to Salmon River. The water-table slopes at a rate of about 60 feet to a mile but steepens to 200 feet to a mile adjacent to Salmon River. The permeability of the sands and gravels would allow at least 60 per cent of the rainfall to penetrate to the water-table and therefore the recharge is in the order of that estimated for Campbell Upland. Free ground water is recovered in the southeast corner of Langley Upland where local deposits of sand and gravel are exposed to the surface and provide infiltration for surface run-off. Elsewhere the aquifers are confined but interconnected as indicated by the static water levels in wells drilled to these aquifers.

Pre-Vashon sands and gravels (1) and Huntingdon gravel (5) are included in the main confined aquifers of this upland. Confined aquifers in pre-Vashon sand and gravel on the west side of the upland yield sufficient water for domestic and stock uses. Huntingdon gravel underlying 50 feet or more of Whatcom stony clay (5) supplies water in sufficient quantity to the users of the Aldergrove community wells. Huntingdon gravel underlying Whatcom stony clay is an important aquifer in an area near Roberts and Coghlan roads. The presence of ground-water bodies at depth is known only from the log of one drilled well at the Naval Station north of Aldergrove. In this well 19 feet of water-bearing sands were encountered below 46 feet of Whatcom stony clay. The water-bearing sands were underlain by 186 feet of Newton stony clay (3) and 78 feet of Surrey till (2). Water in sufficient supply was encountered in loose sand and gravel at a depth of 329 to 336 feet.

Sumas till (8) is present in the east part of the upland as a thin mantle covering hills of low elevation. This till is thin and porous and in places may constitute a free ground-water body. Sumas till, although not an important aquifer, does provide a storage zone for water near the surface and a spring line is present along its thin edges.

Ground-Water Recharge and Discharge

Whatcom stony clay that mantles most of the upland is relatively impervious but sufficient water penetrates it to supply recharge to the Huntingdon gravels. Sumas till where present retards surface run-off and temporarily stores ground water in perched ground-water reservoirs. Abbotsford outwash is porous and provides an excellent infiltration area for rainfall which can penetrate to ground-water storage.

Natural discharge is by means of springs. Those areas capped by Sumas till commonly have a spring line along their lower limits where the till thins. Ground water also discharges in springs along the borders of the Abbotsford outwash in the central part of the upland. One spring from this outwash flows at the rate of 180 gallons an hour and discharges onto Otter Road in NE.$\frac{1}{4}$ sec. 34, tp. 10. Another spring in NW.$\frac{1}{4}$ sec. 33, tp. 10 flows at a rate of more than 16,000 gallons a day.

Recovery of Ground Water

Ground water is recovered by means of springs, dug and drilled wells. Dug wells excepting where Whatcom stony clay is shallow do not yield sufficient water for a continuous supply. Where drilled wells encounter aquifers underlying Whatcom stony clay their depths are less than 200 feet. One well, failing to encounter a suitable aquifer underlying Whatcom stony clay, was drilled to a depth of 484 feet, (see log, page 36). In the northeast part of the area where Whatcom and possibly Newton stony clays may be as much as 300 feet thick and no sands of any extent exist between them, it might be advantageous especially for stock, to build dugouts in the impervious clays where run-off could collect.

FORT LANGLEY UPLAND

The Fort Langley upland is an island of Abbotsford outwash

surrounded by Fraser flood plain deposits. It reaches elevations of 50 feet or more above the surrounding plains. The area is less than 1 square mile. Ground-water reservoirs underlying this upland are probably recharged by water from Fraser River. Wells are dug or drilled up to 85 feet deep and the static level of the water in these conforms with the level of water in Fraser River and the water-table exposed in gravel pits along the southeast side of the upland. The water-table arches slightly under the upland and in the vicinity of the Fort Langley school is about 47 feet below the land surface whereas at the gravel pit it is 6 feet lower. Ground water in perched bodies on the west side of the upland and at lower elevations is high in iron probably due to infiltration of water from Salmon River. A properly developed well drilled to a depth of less than 100 feet in this upland might yield an abundance of water for municipal use as excessive pumping would filter water from the river through the gravel and sand.

LANGLEY LOWLAND

The ground-water reservoirs of Langley Lowland are perched flowing artesian aquifers made up of lenses of coarser silts and sands within the Cloverdale sediments. The aquifers are not continuous but are connected by finer silts that are pervious. Wells are commonly shallower along the sides of the valleys and are deepest along Glover Road. Neighbouring wells may differ as much as 100 feet in depth and in rate of flow from less than 1 gallon to 25 gallons a minute. The hydrostatic head ranges from a few inches to 20 feet.

Water from aquifers in the upland areas bordering the valley moves underground to recharge the coarser lenses of silt and sands within the Cloverdale sediments (4) and the pre-Vashon sands. Flowing artesian wells along the borders of this lowland are shallow, less than 100 feet, and have hydrostatic heads of 20 feet or more. Deeper drilling to 917

feet has not penetrated the sediments in this lowland although 900 feet of Cloverdale sediments (4) were penetrated before encountering coarse water-bearing sands.

About 130 wells have been recorded in Langley Lowland and there are many more. These wells, assuming a rate of flow of 10 gallons an hour, would waste 31,000 gallons a day which is a relatively low estimate.

The ground water is recovered by means of flowing wells the diameters of which are less than 3 inches. Larger diameter wells drilled by means of cable tool rigs may be expected to flow at rates of more than 100 gallons per minute, especially if such wells are drilled to the coarse gravels underlying the Cloverdale sediments.

GLEN VALLEY

The main aquifers in Glen Valley are lenses of sand within Cloverdale sediments (4) but shallow bodies of ground water are also present in the surface Fraser flood plain deposits (10). A perched ground-water body in a deposit of Abbotsford outwash (9) in sec. 29, supplies in the order of 4,000 gallons a day for stock use. Springs along the rim of the valley, as well as gravel benches, are sources of abundant ground water.

USE OF GROUND WATER

Ground water furnishes the principal domestic, industrial and public water supply for Langley municipality. As public knowledge concerning the presence and development of this important resource increases greater and more effective use will be made of ground water.

It is estimated that in Langley municipality 80 per cent of the wells are dug, 18 per cent are drilled or driven, and the remaining 2 per cent utilize natural flow of ground water from springs. The present use of ground water is largely for domestic and stock supplies and some 2 million gallons a day are consumed. Industrial use is limited to dairies, hatcheries and small industries. Two private wells at Aldergrove supply 70 family units with domestic water. Langley has private wells with, in some cases, two or more families using the same well.

DEVELOPMENT OF ADDITIONAL GROUND-WATER SUPPLIES

The direct infiltration of rainfall is in excess of present rate of use of ground water. More ground water is available for development especially in Campbell Upland and Fort Langley Upland where developed wells may be expected to yield in the order of 400 to 500 gallons a minute. Elsewhere wells can be expected to yield sufficient supplies for farm needs. The main aquifers in the uplands are the Abbotsford outwash (9) and Huntingdon gravel (5) and in the lowland areas supplies of flowing artesian water are available from the Cloverdale sediments (4), that in Langley Lowland are as much as 900 feet deep. The outwash deposits are at or near the surface and ample supplies of ground water are available from shallow wells but where large supplies are required as for irrigation a drilled well properly equipped with a screen is recommended. Huntingdon gravel (5) that underlies Whatcom stony clay (7) is a probable source of ground water where outwash deposits are lacking at or near the surface.

In some areas on Clayton and Langley Uplands the underlying succession of strata is such that suitable ground water is difficult to locate within reasonable depths. Most of the wells are in stony clay, are shallow and commonly dry in summer months. The situation may be due to lack of exploratory drilling, test holes abandoned at shallow depth or improper development of aquifers encountered. Deeper wells drilled in these upland areas have established the presence of sufficient ground water at depths of 250 to 500 feet. In most cases the costs of drilling such wells cannot be borne by the individual. Where costs of drilling a well are excessive for the farm income, collection of surface run-off in dugouts would provide water in pasture-lands for stock.

From the records and tests of wells drilled there appears to be ample ground water in Langley municipality. By careful planning, ground water supplies could be developed to meet increased demands for water for farm, domestic, irrigation, municipal and industrial use that may be made in the future.

Pumping tests to determine the safe yield of an aquifer should be carried out before irrigation systems are set up on any well. Wells dug or drilled should be properly constructed as such wells may have a useful life of at least 50 to 100 years.

CHAPTER VI

QUALITY OF WATER

The analytical results of 15 samples of ground water collected in Langley municipality are given in the table on page 34. The samples were collected from the different water-bearing formations and are believed to represent the various types of ground water available in the municipality. The analyses were made by the Mines Branch, Dept. of Mines and Technical Surveys, Ottawa.

The results indicate that good quality soft water is available from the water-bearing formations. Water from aquifers underlying the stony clays and tills have a larger proportion of sodium and bicarbonate.

CHEMICAL CONSTITUENTS IN RELATION TO USE

Hardness.

Hardness presents one of the most important problems in the use of water. Soap, instead of forming a lather, reacts with calcium and magnesium bicarbonates and sulphates to form an insoluble curd. Thus, in hard water much soap is used in softening the water before advantage can be taken of its cleaning and lathering properties.

The hardness of a water is reported as parts per million $CaCO_3$. The total hardness is divided into carbonate hardness, also called temporary hardness, and non-carbonate or permanent hardness. Carbonate hardness is caused by the bicarbonates of calcium and magnesium and can be removed by boiling.

Water having a total hardness of less than 50 ppm. is considered soft and needs no treatment. A hardness of between 50 and 150 ppm. is satisfactory for most uses, but it increases soap consumption and causes considerable boiler scale. The aquifers yield soft water; only one sample analysed has a hardness over 100 ppm. The total hardness in all but one sample is that of the carbonate or temporary nature and can be reduced by boiling the water.

Silica (SiO_2).

Silica has a detrimental effect in some industrial uses, especially in boiler operation where it leads to the formation of hard silicate scales and acts as a cementing agent for softer carbonate scales. The ground water samples show a range in silica from 14 to 35 ppm., and normally surface waters are said to show a silica range of 10 to 30 ppm. The silica content of ground water in Langley municipality would not cause significant trouble to boilers.

Calcium (Ca).

Calcium is usually present as calcium bicarbonate and its presence is due to the action of carbon dioxide and water on limestone, gypsum, and dolomite. In Langley municipality the ground water obtains its calcium from limestone in the glacial drift that was eroded and transported by glaciers to the municipality from areas outside the lower Fraser Valley. Some calcium may be obtained from fossil beds that contain shells with a high calcium content. These fossil beds occur in silts and clays in the unconsolidated deposits of the municipality. The calcium content of the ground water analysed ranges from 45 ppm. to 27.8 ppm.

Magnesium (Mg).

Magnesium, like calcium is derived from dolomite by the same action of carbon dioxide and water. However, magnesium is lower in the samples analysed and this is probably due to the fact that dolomite is not found in the mountain areas bordering the lower Fraser Valley. Sea water is also a probable source of magnesium.

Sodium (Na) and Potassium (K).

Sodium and potassium are the principal alkalis determined in the water analysis. They are present as chloride, sulphate and bicarbonates. Their sources are rock salt, interbedded with or disseminated through sedimentary bedrock formations; sea water, either directly or from that enclosed in sediments of marine origin; feldspars and certain other sodium and potassium-bearing minerals. A high percentage of sodium in water used for irrigation affects both the crops and the soil to which the

water is applied. However, high percentages of sodium can be tolerated if the dissolved solids are low as indicated in those samples analysed from water-bearing formations in Langley municipality.

Those ground waters that have percolated through the marine stony clays have a higher sodium content than ground water from other aquifers in Langley municipality.

Bicarbonate (HCO_3).

Carbon dioxide dissolved in water renders the insoluble calcium and magnesium carbonate soluble as bicarbonates. Boiling reverses the process by changing the bicarbonates into insoluble carbonates that precipitate out of solution and may form a coating on the side of cooking utensils.

Sulphate (SO_4).

The main source of sulphate in ground water is gypsum ($CaSO_4.2H_2O$) and metallic sulphide such as pyrite (FeS_2). Pyrite is believed to be the chief source of the sulphate in Langley municipality. The sulphate content of the samples analysed ranges from 0 to 43.4, the higher sulphates being in ground water derived from the Cloverdale sediments and they may be in part derived from H_2S (hydrogen sulphide gas).

Chloride (Cl).

Chlorides are derived from organic materials or from sea water either directly or indirectly. In those samples analysed the chloride content is noticeably higher in the ground water from aquifers in the lowland areas that were deposited in embayments of the sea at an earlier geological time. Ground water of the upland areas especially areas of outwash are low in chlorides and the source of those present is probably organic. More than 300 ppm. are required to impart the salty taste to water.

Fluoride (Fl).

The source of fluorides are rocks and soils containing varying amounts of fluorine. Within recent years the importance of fluorides in connection with tooth decay has been investigated in many cities either with natural fluoride or the introduction of fluorides in the city water supply.

A fluoride concentration of less than 1.5 ppm. is considered beneficial to the calcification of teeth in children.

Nitrate (NO_3).

Most nitrates found in ground water are due to the presence of vegetable or animal matter. Nitrates in larger amounts, more than 10 - 20 ppm., commonly indicate pollution of considerable extent. Therefore, a high nitrate concentration should necessitate an investigation of all possible sources of pollution.

ANALYSES OF WELL WATERS FROM LANGLEY MUNICIPALITY, B. C.

Owner	Location ¼	Sec.	Tp.	Sum of Constituents	SiO_2 (Col)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	Fl	NO_3	Hardness as $CaCO_3$ Total	CO_3	Non-CO_3
Super Valu	NE	2	8	679.6	43	11.1	5.9	224	7.6	212	44	228	0.1	6.0	52	52	0.0
D. Peacock	NE	3	8	641	34	12.6	5.7	216	14	222	43.4	201	0.2	0.8	54.9	54.9	0.0
W.M. Jensen	NW	7	10	247	35	7.2	2.6	80.2	1.8	236	0	2.1	1.0	0.8	28.7	28.7	0.0
D.C. Derksen	SW	3	10	245	20	4.5	1.3	86.8	2.7	249	3.1	2.3	0.5	0.8	16.6	16.6	0.0
B. Greer	SE	26	10	105.3	31	13.5	6.7	5.9	1.7	90.0	0	1.1	0.1	0.6	61.2	61.2	0.0
D.W. Poppy	NW	26	10	78.8	27	9.0	4.9	3.9	1.1	60.5	0.4	1.4	0	1.6	42.4	42.4	0.0
C. Ooms	NW	28	10	63.0	24	7.3	2.7	4.1	0.5	46.0	0.5	0.7	0.1	0.2	29.3	29.3	0.0
Maple Leaf Hatchery	NE	31	10	409	34	5.9	0.3	154	3.8	397	1.1	1.9	0.8	1.2	16.0	16.0	0.0
P.Y. Porter	NW	31	10	175.2	29	27.8	10.5	13.6	3.3	163	6.4	2.9	0.0	0.8	112.5	112.5	0.0
Anderson Engineering Co.	NW	32	10	200	20	11.1	6.0	52.8	5.5	197	2.8	1.4	0.3	0.2	52.4	52.4	0.0
A.C. Taylor	NW	17	11	408	22	11.0	4.0	138	4.9	242	20.5	80	- -	1.2	43.9	43.9	0.0
C.E. Hall	SE	26	11	150	19	11.9	5.2	29.1	5.4	114	14.2	8.3	0.1	0.4	51.1	51.1	0.0
Fort Langley School	SE	32	11	134.3	14	14.3	3.9	23.8	1.0	39.0	8.2	34.1	0.04	16.0	51.7	51.7	0.0
B. Keet	SW	33	11	137.0	15	15.5	3.7	23.2	1.2	45.6	6.9	42.8	0.0	6.0	53.9	37.4	16.5
Naval Radio Station	NE	30	13	970.0	34	12.8	7.2	352	5.2	615	53.7	194	0.6	8.0	61.5	61.5	0.0

All figures are in parts per million

MATERIALS PENETRATED BY REPRESENTATIVE WELLS AND TEST HOLES IN LANGLEY MUNICIPALITY

Material	Thick-ness (feet)	Depth (feet)	Formation
Well No. 1, NE¼ sec. 24, tp. 7			
clay, some stones	20	20	Whatcom and probably Newton stony clay
clay, silt, sand, boulders	37	57	Surrey till
sand	6	63	Quadra sediments
Well No. 1, NE¼ sec. 2, tp. 8	Super Valu Store, Langley		
clay and silt	197	197	Cloverdale sediments
silt, lenses of fine sand	58	255	" "
sand, some gravel	50	305	" "
sand, coarse, gravel	1	306	" "
Well No. 2, SW¼ sec. 22, tp. 8 (C.C. Heady)			
clay pebbles	20	20	Newton stony clay
clay, silt, sand, compact boulders	80	100	Surrey till
sand	20	120	Pre-Vashon
sand, fine, coarse at depth	102	222	Pre-Vashon
Well No. 1, SW¼ sec. 25, tp. 8			
clay	28	28	Newton stony clay
clay, sand, boulders, compact	42	70	Surrey till
Drilling discontinued at 70 ft.			
Well No. 3, NW¼ sec. 26, tp. 8			
clay	44	44	Whatcom and probably Newton stony clay
hardpan	10	54	Surrey till
sand, coarse	12	66	Pre-Vashon
sand, fine, water-bearing	27	93	" "
sand	12	105	" "
clay	2	107	" "
sand	5	109	" "
silt, clay	12	121	" "
sand	6	127	" "
Well No. 3, SE¼ sec. 3, tp. 10			
clay, stones	55	55	Whatcom and possibly Newton stony clay
"hardpan"	30	85	Surrey till
gravel	1	86	Pre-Vashon
Well No. 3, NW¼ sec. 7, tp. 10			
clay	65	65	Whatcom and possibly Newton stony clay
"hardpan"	65	130	Surrey till
sand, dry	30	160	Pre-Vashon
sand, gravel	14	174	" "

Material	Thickness (feet)	Depth (feet)	Formation
Well No. 2, SE¼ sec. 26, tp. 10			
clay	50	50	Whatcom and possibly Newton stony clay
"hardpan"	90	140	Surrey till
sand, fine to medium	38	178	Pre-Vashon
gravel	2	180	" "
Well No. 3, SE¼ sec. 26, tp. 10			
clay	85	85	Whatcom and possibly Newton stony clay
"hardpan"	26	111	Surrey till
sand and clay	49	160	Pre-Vashon
sand and gravel	19	179	" "
Well No. 1, NE¼ sec. 31, tp. 10 (Maple Leaf Hatchery)			
clay	50	50	Whatcom and possibly Newton stony clay
"hardpan"	40	90	Surrey till
clay, fine sand	20	110	Semiamu sediments
"hardpan"	60	170	Semiamu till
gravel	6	176	Quadra
Well No. 3, NW¼ sec. 17, tp. 11 (A.C. Taylor)			
silt, clay pebbles, water at 659 ft.	659	659	Cloverdale sediments
silt and clay compact	65	724	" "
gravel and sand, dirty	2	726	" "
sand, gravel, salty water	6	732	" "
sand, fine	23	755	" "
sand, fine, silt and clay	76	831	" "
clay	4	835	" "
sand, fine, silty, clay bits of wood, salty water	55	890	" "
sand and gravel	10	900	" "
gravel, coarse, water	5	905	" "
gravel, very coarse, water flows at rate of 100 g.p.m.	12	917	" "
Well No. 1, NE¼ sec. 30, tp. 13 (Aldergrove Naval Radio Station)			
clay, brown to grey	46	46	Whatcom stony clay
sand, gravel, some water at 58 ft.	19	65	Huntingdon gravel
clay, sticky blue	186	251	Newton stony clay
boulders, gravel, sand, clay	78	329	Surrey till
sand and gravel, loose	7	336	Semiamu sediments
boulders, gravel, sand, clay	20	356	Semiamu till
sand, loose, water, sandy clay	128	484	Quadra sediments

COMPILATION OF WELL DATA

The following information and abbreviations pertain to the well records of Langley municipality.

Description of Well

Type of well

Dr - drilled, well made by standard drilling rig.

Dn - driven (sandpoint)

Dg - dug or hand augered

Br - well bored by power-driven auger

Sp - spring

Type of casing

C - concrete

I - standard galvanized iron pipe

S - standard black pipe

W - wood cribbing

T - till

Collar elevation

The elevations are with reference to mean sea-level, and are believed accurate to within 5 feet.

Static level

The static level is the level of the water with respect to the ground level at the collar of the well. Where the level is positive the water rises above the ground and the well is a flowing artesian.

Principal aquifers

Depth to top

The depths are the reported depths to the top of the main water-bearing deposits, and are believed to be accurate within 5 feet.

Character of material

The character of the material is that observed by the writer or that reported and believed reliable.

Sd - sand

Gr - gravel

Bd - boulders

St - sandy till

Si - silt

F - fine

Cs - coarse

Formation

Ab - Abbotsford

Cl - Cloverdale

F F - Fraser Flood plain deposits

Hn - Huntingdon

P V - Pre-Vashon

Sm T - Sumas Till

Ss - Sunnyside

Sr T - Surrey Till

Water.

Use

Dm - domestic

Ir - irrigation

St - stock

In - industrial

C O - cooling purposes only

N U - not used

D H - dry hole

Yield.

Gals/hr. imperial gallons per hour.

Not all the yields reported were measured by the writer, some were reported by the well owners and believed reliable.

REPRESENTATIVE WELL RECORDS OF LANGLEY MUNICIPALITY, BRITISH COLUMBIA

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (feet)	Collar Elev. (feet)	Static Level (feet)	Depth to top (feet)	Character of material	Formation	Quality	Use	(gals hr.)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
7	2	SE	1	Dg	W 48	26	292	- 16	25	Sd gr	P V	Clear, soft	Dm St	- - -	Seasonal Fluctuations
7	10	NE	1	Dg	C 60	42	260	- 20	12	S t	Sr T	Hard	Dm	- - -	Limited supply from sand lens in Surrey till
7	13	SE	1	Dr	S 3	72	245	- 15?	---	Sd	P V	Clear, soft	Dm	- - -	
7	13	NW	2	Dg	W 48	8.5	180	- 5	0	Gr	Ab	Clear, soft	Dm	- - -	
7	14	SE	1	Dr	S 4	115	215	- 20	60,80	Sd	P V	Clear, soft	Dm	360	Fine sand filled in bottom of well from 90-115 ft.
7	14	NW	2	Dn	S 1½	32	165	- 15	0	Sd gr	Ab	Clear, soft	Dm St	- - -	
7	14	NE	3	Dg	W 36	13	180	- 8	0	Sd gr	Ab	Clear, soft	Dm	- - -	
7	15	NE	1	Dn	I 2	22	165	- 18	0	Sd gr	Ab	soft	Dm St	- - -	
7	15	SE	2	Dg	- 48	22	185	- 14	0	Sd gr	Ab	soft	Dm St	- - -	
7	15	SE	3	Dr	S 4	134	170	-104	130?	Gr	P V	soft	Dm	- - -	Drilled 1955 log incomplete
7	22	NE	1	Dn	I 1¼	24	164	- 15	0	Sd gr	Ab	soft	Dm St	- - -	
7	22	SE	2	Dn	I 2	24	164	- 14	0	Sd gr	Ab	soft	Dm Ir	- - -	
7	22	SE	3	Dn	I 1¼	15	157	- 14	0	Sd gr	Ab	soft	Dm Ir	- - -	
7	23	SE	1	Dg	C 36	12	175	- .7	0	Sd gr	Ab	soft	Dm	- - -	
7	23	NW	2	Dg	- 60	24	166	- 10	0	Sd gr	Ab	hard	Dm St	- - -	
7	24	NE	1	Dr	S 4	63	190	- 20	57	Sd	P V	Good, clear	Dm St	- - -	Drilled 1954; see log
7	24	SW	2	Dg	C 36	12	180	- 9	0	Sd gr	Ab	Good, clear	Dm	- - -	
7	24	NE	3	Dr	S 4	94	175	- 10	---	F sd	P V	clear	Dm	- - -	
7	25	NW	1	Dg	W 48	21	170	- 14	0	Sd gr	Ab	Soft, clear	Dm	- - -	
7	26	NW	1	Dr	-	30	160	-	0	Sd gr	Ab	Soft, clear	Dm	- - -	Well at Belmont School
7	27	SE	1	Dg	C 36	25	164	- 12	0	Sd gr	Ab	Soft	Dm St	- - -	
7	34	NE	1	Dg	C 36	12	110	- 5	0	Sd gr	Ab	Soft	Dm St	- - -	
7	34	NE	2	Dg	W 60	40	110	- 36	0	Sd gr	Ab	Soft	Dm St	- - -	
7	34	NE	3	Dg	W 30	36	140	- 31	0	Sd gr	Ab	Soft	Dm St	- - -	
7	34	SE	4	Dn	I 4	45	140	- 40	0	Sd gr	Ab	Soft	Dm St	- - -	
7	34	SE	5	Dg	C 36	51	140	- 48	51	Sd	P V	Soft	Dm Ir	- - -	
7	35	NE	1	Dg	C 36	36	150	- 30	0	Sd gr	Ab	Soft	Dm	- - -	
7	36	SE	1	Dg	W 48	13	160	- 7	0	Sd gr	Ab	Soft	Dm	- - -	
7	36	SE	2	Dr	S 6	90	160	- 45	---	---	--	Soft	Dm St	- - -	Log incomplete

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
8	1	SE	1	Dr	I 2	240	40	+ 20	240	F sd	Cl	Soft	Dm	120	Temp. of water 52°F.
8	1	SE	2	Dr	I 2	282	39	+ 26	280	Sd	Cl	Soft	Dm	180	Natural flow
8	1	SW	3	Dr	I 2	359	60	+ 2	358	Sd	Cl	Soft	Dm	150	Natural flow
8	2	NE	1	Dr	S 4	306	30	?	306	Sd gr	Cl		Dm	27	See log; see analysis. Well at Super Valu Market
8	2	NW	2	Dr	I 2	254	30	+ 15	240	Gr	Cl	Good, clear	Dm	154	Temp. of water 50°F.
8	3	NE	1	Dr	S 4	350	42	+ 1	340	Sd	Cl	Soft	Dm	300	Temp. of water 50°F. See analysis
8	3	NE	2	Dr	I 1.5	311	25	+ 15	300	Gr	Cl	Soft	Dm	60	Supplies 5 houses
8	3	SE	3	Dg	C 36	9	60	- 2	0	Sd	Ss	Soft	Dm St		Perched water-table well
8	3	SW	4	Dr	I 4	165	30	+ 1	100	Sd gr	Cl	Soft	Dm St	50	Natural flow
8	10	NE	1	Dr	I 2	88	60	0	80	Sd gr	Cl	Soft	Dm St		
8	10	SE	2	Dr	I 1.5	197	45	0	194	Cs sd	Cl	Soft	Dm St	40	Natural flow
8	10	SE	3	Dr	I 2	260	30	+ 2	160	Gr	Cl	Soft	Dm Ir	20	Natural flow
8	10	SW	4	Dn	I 2	61	70	+ 1	60	Gr	Cl	Soft	Dm St	---	
8	10	NW	5	Dg	C 24	22	100	- 20	20	Sd gr	P V	Soft	Dm St	---	
8	10	NW	6	Dr	I 3	240	144	- 60	---	Sd gr	P V	Soft	Dm St	---	Log incomplete
8	10	NW	7	Dr	I 5	50	132	- 44	40	Sd gr	P V	Soft	Dm St	---	
8	11	NE	1	Dr	S 2	282	46	+ 5	282	Sd gr	Cl	Sulphur	Dm	120	Drilled 5 holes all yielded poor water
8	11	NW	2	Dr	I 2	255	65	+ 6	255	Sd	Cl	Sulphur	Dm St	40	Temp. of water 50°F.
8	12	SE	1	Dr	S 3	350	33	+ 3	350	Sd	Cl	Soft		60	Temp. of water 50°F. well at Exhibition Grounds
8	12	NE	2	Dr	I 2	590	26	+ 20		Sd?	Cl	Sulphur	Dm	52	Log incomplete
8	13	SE	1	Dr	S 2	353	38	+ 15?		---	Cl		In	2400	Well at Wishing Well Bev. Co.
8	14	SW	1	Dr	S 4	108	74	- 8	100	Gr	P V	Soft, clear	Dm St	---	Temp. of water 48°F.
8	15	NE	1	Dg	C 36	45	140	- 30	45	Gr	P V	Soft	Dm St	---	
8	15	SE	2	Dg	C 48	27	150	- 23	---	Gr	P V	Soft	Dm St	---	Log incomplete
8	15	SE	3	Dr	I 3	240	63	0	190	Gr	P V	Soft	Dm St	---	Log incomplete
8	15	SW	4	Dg	C 48	21	120	- 19	21	Sd	P V	Soft	Dm St	---	Log incomplete
8	22	NE	1	Dr	S 4	180	222	-100	80,180	Sd	P V	Sulphur	Dm St	---	Log incomplete. A log of wood encountered at elevation 47 ft.
8	22	SW	2	Dr	S 8	222	257	-158	208, 220	Sd	P V	Soft	Dm St		See analysis
													Ir	4800	See log
8	24	SE	1	Dr	S 2	148	47	+ 5	---	Sd	Cl	Soft, clear	Dm St	60	Natural flow
8	24	SE	2	Dr	S 3	36	60	+ 8	36	Sd gr	Cl?	Soft	Dm St	270	Temp. of water 50°F.
8	24	NE	3	Dr	S 6	132	---	---	---	---	--				Drilling discontinued at 132 ft.
8	24	SE	4	Dr	S 4	52	73	?		Sd gr	P V?	Soft	Dm St	180	Natural flow

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
8	25	SW	1	Dr	---	70	249	---	---	---	---				Dry hole. See log
8	26	NE	1	Dr	S 4	157	190	-117	---	F sd	---		N U		Log incomplete. Hole filled with fine sand
8	26	NW	2	Dg	C 36	63	140	- 60	50	F sd	P V	Soft	Dm St		Uses about 1,000 gallons a day
8	26	NW	3	Dr	S 4	127	135	- 28	---	F sd	P V				See log. Fine sand prevented development of well
8	27	NE	1	Dr	I 2	120	75	0	100	Sd	---	Soft	Dm St	75	Natural flow
8	27	SW	2	Dg	- 48	23	148	- 20	18	Gr	P V	Soft	Dm St		
8	27	SW	3	Dg	- 48	40	182	- 35	40	Gr	P V	Soft	Dm St		
8	27	SW	4	Dg	C 36	8	69	- 7	0	Sd	Ss	Soft	Dm St		
8	27	NW	5	Dg	C 48	9	50	- 7	0	Sd	Ss	Soft	Dm St		
8	34	NE	1	Dg	C 36	14	40	- 10	8	Gr	P V	Soft	Dm St		
8	34	SE	2	Dg	C 36	9	79	- 7	0	Sd	Ss	Soft	Dm St		
8	35	NE	1	Dn	---	9	86	- 8	0	Sd	Ss	Soft	Dm St		
8	35	SW	2	Dr	---	44	50	+ 4	40	Sd	---?	Sulphur	Dm St	40	Natural flow
8	36	NE	1	Dr	I 1½	480	50	---	230, 260, 280	Sd	---?	Good	Dm St		Salty water to 230 and 260
9	1	SE	1	Dr	I 3	550	52	+ 10	---	Sd	---?	Salty	C 0		Log incomplete
9	2	SW	1	Dg	T 18	16	28	- 13	---	Gr	Ab?	Soft	Dm		
9	2	NE	2	Dg	C 36	12	10	- 9	0	Gr	F F	Soft	Dm		Uses 3,000 gallons a day
9	3	NE	1	Dg	C 36	7	13	- 5	0	Gr	F F	Soft	Dm St	10,000	Estimated yield
9	3	SE	2	Dg	C 30	10	48	- 6	5	Gr	Ab	Soft	Dm		
9	3	SW	3	Dg	C 36	12	47	- 6	0	Gr	F F	Soft	Dm		
9	12	NE	1	Dg	C 36	18	10	- 15	0	Si sd	F F	Soft, iron	Dm		
10	1	SW	1	Dg	C 36	12	168	- 8	---	Gr	Ab	Clear, gocd	Dm		
10	3	SE	1	Dr	S 5	120	252	- 30	---	Sd	Hn?	Clear, good	Dm St		
10	3	SE	2	Dr	S 4	87	217	- 16	86	Sd	Hn?	Clear, good	Dm St		
10	3	SE	3	Dr	S 5	86	211	- 10	55,85	Gr	Hn?		Dm St	150	See analysis. See log.
10	6	NE	1	Dg	C 36	54	237	- 42	54	Gr	Hn?	Soft	Dm St		
10	7	SW	1	Dr	S 4	100	235	- 91	95	Gr	P V	Soft	Dm St		
10	7	NW	2	Dr	S 4	150	319	- 144	149	Bd	P V	Soft	---	200	See log
10	7	NW	3	Dr	S 4	174	356	- 160	160	Gr	P V	Yellow in colour	Dm St	152	See analysis; see log. Drawdown 3 ft. 7 in.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
10	8	NW	1	Dr	S 4	108	260	- 50	98	Gr	P V	Yellow in colour	Dm St		
10	8	SW	2	Dr	S 5	186	260	—	186	Gr	P V	Yellow in colour	Dm St		
10	9	SE	1	Dr	S 4	157	260	- 57	---	Gr	P V	Clear, good	Dm St		
10	14	SW	1	Dr	S 4	90	229	- 40	45,89	Gr	Hn?	Iron	Dm		Well was drilled 115 feet, filled with sand to 90 feet. Water from sand at 45 and 89 feet
10	14	SE	2	Br	W 24	82	281	- 42	82	F sd	Hn?	Soft, clear	Dm St		
10	14	NE	3	Dg	W 60	90	289	- 25	90	Sd	Hn?	Soft, clear	Dm St		Water supply for 5,000 poultry
10	15	SW	1	Dr	S 4	54	264	- 36	54	Sd	P V	Soft, clear	Dm St		Well drilled in summer of 1954
10	16	NE	1	Dr	S 4	110	346	- 102	110	Sd	P V	Soft, clear	Dm		
10	16	SE	2	Dr	S 4	102	286	---	---	Sd	P V	Good, clear	Dm St	420	
10	17	SE	1	Dr	S 5	186	266	- 40	100, 186	Sd	P V	Good, clear	Dm		
10	17	SW	2	Dr	S 4	125	251	---	---	F sd	P V	Yellow in colour	Dm St		
10	17	SW	3	Dr	S 5	82	257	---	---	Sd	P V	Yellow in colour	Dm St		
10	17	NW	4	Dr	S 4	153	259	- 60	150	Sd	P V	Yellow in colour	Dm St		Uses 1,000 gallons a day
10	17	NE	5	Dr	S 4	112	256	- 32	110	Sd	P V	Yellow in colour	St		Water has a sulphur odour
10	18	SE	1	Dr	S 4	150	252	- 50	150	Gr	P V	Good, clear	Dm		Test pumped for a period of 24 hours no record kept
10	18	SE	2	Dr	S 5	140	324	- 131	140	Gr	P V	Good, clear	Dm St		
10	19	SE	1	Dr	S 5	221	300	---	---	---	---		D H		Some water at 221 feet; but pumped ou in 15 minutes
10	22	NE	1	Dr	S 5	243	420	---	---	F sd	Hn		D H		
10	25	SE	1	Dr	S 4	267	364	---	---	---	---	Iron	Dm		
10	25	NW	2	Dr	S 4	90	380	- 50	90	Sd	Hn	Good, clear	Dm		Water in sand below stony clay
10	25	NW	3	Dr	S 4	136	354	- 85	136	Sd	Hn	Good, clear	Dm St		
10	26	SE	1	Dr	S 4	125	420						D H		Hole not drilled to aquifer, should be deepened
10	26	SE	2	Dr	S 4	180	411	- 130	178	Gr	Hn	Good, clear	Dm St		See log
10	26	SE	3	Dr	S 5	179	391	---	160		Hn	Good, clear	Dm		See log
10	26	SW	4	Dr	S 6	125	339	- 70	99	Sd	Hn	Good, clear	Dm		

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
10	26	NW	5	Dr	S 6	171	360	- 100	116,145 170	Gr	Hn?	Good, clear	Dm St	300	See analysis
10	26	NW	6	Dg	W 48	12	348	- 5	0	Gr	Ab	Good, clear	Dm		A water-table well
10	26	NW	7	Dg	C 36	60	332	- 58	29	Gr	Hn?	Good, clear	Dm		
10	26	NE	8	Dr	S 4	122	350	- 114	122	Sd	Hn	Good, clear	Dm St		Water in sand below stony clay
10	26	NE	9	Dr	S 4	100	384	- 70	100	Sd	Hn	Good, clear	Dm St		
10	27	SE	1	Dr	S 10	300+	425	---	---		---	---	Dm St		Well at Otter Farmer's Institute, drilled originally in search of oil. Supplies 7 farms besides the Institute
10	27	NE	2	Dg	C 42	13	328	- 10	0	Gr	Ab	Good, clear	Dm		
10	27	NE	3	Dr	S 4	110	334	- 85		---	---	Good, clear	Dm		Log incomplete
10	27	NE	4	Dr	S 3	76	332	- 64		F sd	Hn	Good, clear	Dm		
10	27	NE	5	Dr	S 4	80	326	- 63		Gr	Hn	Good, clear	Dm	800	Test pumped at rate of 800 gals./hr. for 21 days
10	27	NW	6	Dr	S 4	76	329	- 64	74	Sd	Hn	Good, clear	Dm		
10	27	NW	7	Dr	S 5	90	320	- 88		Sd	Hn	Good, clear	Dm		Uses 1,000 gals/day
10	28	SE	1	Dr	S 4	94	343	- 74		Sd	Hn	Good, clear	Dm St		Log incomplete
10	28	SE	2	Dr	S 4	78	312	- 42	40	Sd	Hn	Good, clear	Dm St		Water in sand below stony clay
10	28	NW	3	Dr	S 4	90	345	- 76	9	Gr	Hn	Good, clear	Dm		See analyses
10	30	NE	1	Dr	S 4	156	184	- 14	154	Sd	P V	Good, clear	Dm St		
10	30	SW	2	Dr	S 4	60	150	+ --	60	Sd	Hn?	Good, clear	Dm St		Water flows over top of casing at ground surface.
10	31	NE	1	Dr	S 4	176	202	- 26	170	Gr	P V	Good, clear	Dm		See log; see analyses
10	31	NW	2	Dr	S 2	72	70	+ 2	45	Gr	Cl?	Good, clear	Dm	30	See analyses
10	31	NW	3	Dr	S 5	136	140	- 11		---	---	Good, clear	Dm		Log incomplete
10	32	SE	1	Sp		11	230	Surface	11	Gr	Hn	Clear, good	Dm St		Gravel below 11 feet of clay
10	32	SE	2	Dg	- 48	57	229	- 5	41	Gr	Hn	Clear, good	Dm St		Decreases seasonally
10	32	NW	3	Dr	S 5	107	225	- 3	107	Sd	Hn	Clear, good	Dm		Well at Langholm
10	32	NW	4	Dr	S 4	137	209	---	---	Sd	Hn	Clear, good	Dm St		Log incomplete
10	32	NW	5	Dr	S 4	136	212	- 20	80,135	Sd	Hn	Clear, good	Dm	150	See analyses; 20 gal/hr. at 80 feet
10	32	NW	6	Dr	S 6	111	212	- 60	---	---	---	Clear, good	Dm		Not sufficient, well at Auto court
10	32	NE	7	Dr	S 4	42	223	Surface	42	Sd	Hn	Clear, good	Dm St		Water in sand below 42 feet of stony clay
10	32	NE	8	Dr	S 4	52	205	Surface	52	Sd	Hn	Clear, good	Dm		Drilled July 1955
10	33	SE	1	Dg	- 48	70	326	- 66	35	Sd	Hn	Clear, good	Dm		Supplies 20 people
10	33	SE	2	Dr	S 5	110	330	- 85	---	---	---	Clear, good	Dm		Log incomplete
10	33	SW	3	Dg	C 32	39	269	- 36	---	Gr	Hn	Clear, good	Dm		Lens or pod of gravel in Surrey Till?
10	33	NW	4	Sp	---	---	233	Surface	---	Sd	Ab	Clear, good	Dm		
10	33	NW	5	Sp	---	---	242	Surface	---	Sd	Ab	Clear, good	Dm		Water rights posted 16,000 gals./day

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
10	33	NW	6	Dg	---	43	266	- 40	0	Sd gr	Ab	Clear, good	Dm		Water first at 25 ft.
10	33	NW	7	Dg	W 24	23	271	- 13	0	Sd gr	Ab	Clear, good	Dm		
10	33	NE	8	Dg	C 36	36	277	- 33	0	Gr	Ab	Clear, good	Dm		
10	34	SE	1	Dr	S 6	110	315	- 80	65	F sd	Hn	Clear, good	Dm		Log incomplete
10	34	NW	2	Dg	C 36	18	276	- 12	0	Gr	Ab	Clear, good	Dm St		
10	34	NE	3	Sp	---	---	261	Surface	0	Sd gr	Ab	Clear, good	Dm St	180	Temp. of water 47°F.
10	36	NE	1	Dr	S 4	170	344	- 70	---	Sd	Hn	Clear, good	Dm		
10	36	NE	2	Dr	S 4	55	334	- 32	---	Sd	Hn	Clear, good	Dm St		
10	36	NE	3	Dr	S 4	165	341	- 155		F sd	Hn	--- ---	---		Well never developed
10	36	NW	4	Dg	C 36	16	290	- 8	0	Gr	Ab	Clear, good	Dm St		
11	1	NW	1	Br	C 36	57	313	- 42		Gr	Hn	Clear, good	Dm St		
11	3	NE	1	Dg	W 24	24	282	- 20	0	Gr	Ab	Clear, good	Dm St		
11	3	NW	2	Dg	C 36	53	282	- 48	0	Gr	Ab	Clear, good	Dm St		
11	4	SE	1	Dg	C 36	48	281	- 43	0	Gr	Ab	Clear, good	Dm		Supplies 6 families
11	4	NE	2	Dg	C 36	86	278	- 74	0	Gr	Ab	Clear, good	Dm		
11	5	SE	1	Dr	S 4	67	195	- 4	---	Gr	Hn	Clear, good	Dm St		
11	5	NW	2	Dr	S 4	180	114	- 50		---	---	---	---		Drawdown exceeds 180 ft.
11	5	NE	3	Dr	S 2	80	96	+ 15		Sd	Cl	Clear, good	Dm		Natural flow
11	6	SE	1	Dr	S 4	61	199	- 51	60	Sd	Hn	Clear, good	Dm		
11	6	SE	2	Dr	S 6	204	204	- 50	---	F sd	P V?	Clear, good	Dm		
11	6	SW	3	Dr	S 2	220	40	+ 12	220	Sd	Cl	Clear, good	In	1,200	Temp. of water 50°F. Well at Seal Cap Dairy
11	6	SW	4	Dr	I $1\frac{1}{2}$	75	67	+ 2	75	Sd	Cl	Clear, good	Dm		
11	6	NE	5	Dr	I $1\frac{1}{2}$	42	67	+ 9	42	Sd	Cl	Clear, good	St	120	Temp. of water 50°F.
11	6	NW	6	Dr	S 2	256	40	+ 14	250	Sd	Cl	Clear, good	Dm	60	Temp. of water 50°F.
11	7	SW	1	Dr	S 2	331	40	+ 20	300	Gr	Cl	Clear, good	Dm St	2,100	
11	7	NW	2	Dr	S 3	306	46	---	290	Sd	Cl	Clear, good	St	420	Temp. of water 50°F.
11	8	SE	1	Dr	S 4	75	90	+ 13	60	Sd	Cl	Clear, good	Dm St	500	Natural flow.
11	8	NW	2	Dr	S $1\frac{1}{4}$	300	62	+ 6	300	Sd	Cl	Clear, good	St		Two wells each 300 ft. deep. Natural flow
11	10	SE	1	Dg	C 36	78	284	- 75	---	Gr sd	Ab	Good, clear	Dm St		
11	11	NE	1	Dr	S 4	40	276	- 15	35	Sd	Hn	Good, clear	Dm		Water in sand below stony clay
11	12	SW	1	Dr	S 4	212	310	- 147		F sd	Hn	Good, clear	Dm St		Well drilled 1955
11	12	SW	2	Dr	S 4	82	316	---		F sd	Hn	Good, clear	St		
11	12	NW	3	Dr	S 4	70	305	---	70	Gr	Hn	Good, clear	Dm St		
11	12	NW	4	Dr	S 4	50	286	- 15	49	Sd	Hn	Good, clear	Dm St		

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
11	12	NE	5	Dg	C 36	42	318	- 33	---	Sd	Hn	Good, clear	St		
11	13	NE	6	Dr	S 4	55	339	---	---	Sd?	Hn	---	Dm		Well at County Line School
11	13	SW	1	Dr	S 4	75	296	- 15	75	Sd	Hn	Good, clear	Dm St Ir		
11	14	SE	1	Dr	S 4	60	299	- 15	---	Sd	Hn	Good, clear			
11	14	SE	2	Dr	S 4	60	290	- 14		Sd	Hn	Good, clear			
11	14	SW	3	Dg	C 32	68	253	- 62		Sd	Hn	Good, clear	Dm		
11	15	SW	1	Dg	C 36	55	183	- 52	---	Gr	Ab	Good, clear	Dm		
11	15	NW	2	Dr	I 3	76	183	- 74	---	Gr	Ab	Good, clear	Dm		Supplies 4 families.
11	16	NE	1	Sp	C --	2	138	Surface	0	Sd	Ab	Good, clear	Dm		
11	17	SE	1	Dr	S $3\frac{1}{2}$	135	75	+ 12	80	Sd	Cl	Good, clear	Dm St		Natural flow.
11	17	NE	2	Dr	I 2	285	72	+ 14	---	Sd	Cl	Good, clear	Dm St	60	Temp. of water 49°F.
11	17	NW	3	Dr	S 10	917	51	?	900	Cs gr sd	Cl	Good, clear	Dm St	6,000	Temp. of water 56°F. See analyses. See log.
11	18	SW	1	Dr	I 3	422	40	+ 30	300	Gr	Cl	Good, clear		2,000	
11	18	SW	2	Dr	---	497	43	---	475	Sd	Cl	Good, clear		180	Salty water at 350 feet.
11	19	SE	1	Dr	I $2\frac{1}{2}$	360	35	+ 20	360	Sd	Cl	Brackish	Dm	240	Temp. of water 48°F.
11	19	NE	2	Dr	I $1\frac{1}{2}$	325	30	+ 20	300	Sd	Cl			360	Temp. of water 50°F.
11	20	SE	1	Dr	S 2	150	33	+ $22\frac{1}{2}$	---	Sd	Cl	Good, clear	Dm	53	Temp. of water 49°F.
11	20	SW	2	Dr	S 2	456	43	+ 19	---	---	Cl	Good, clear			Drilled 1955
11	21	SW	1	Sp	C 8	$1\frac{1}{2}$	90	Surface	0	---	---	Good, clear	Dm	2	Temp. of water 47°F.
11	21	SW	2	Dr	I 2	165	74	+ 2	---	Sd	Cl	Sulphur	Dm	48	Temp. of water 49°F.
11	22	SW	1	Dr	S 4	92	188	- 56	---	---	Hn	Good, clear			
11	22	SW	2	Dr	S 4	80	209	---	---	Gr	Hn	Good, clear			
11	22	NE	3	Dr	S 4	94	204	- 80	---	Gr	Hn	Good, clear		50	
11	22	NW	4	Dg	C 26	65	184	- 62	10	Sd	Hn	Good, clear			
11	22	NW	5	Dr	S 4	203	247	---	195	F sd	P V?	Good, clear			Well drilled 195, Sandpoint driven 8 feet into aquifer
11	24	SE	1	Dr	S 4	180	242			F sd	Hn	Dry hole			Some water but couldn't develop
11	25	SW	1	Dn	---	12	28	---	0	Sd	F F	Good, clear	Dm		Well at East Langley School
11	25	SW	2	Dg	C 36	13	33	- 9	0	Sd	F F	Good, clear	Dm		
11	26	SE	1	Dr	S $1\frac{1}{4}$	430	44	+ 14	---	Gr	Cl		Dm St		Salt water at 200 ft. See analysis
11	26	SW	2	Dr	I 3	240	26	+ 24	---	F sd	Cl	Good, clear	Dm St	5,600	Natural flow
11	29	SW	1	Dr	I 2	127	53	+ 4	---	---	Cl	Good, clear	Dm	40	Temp. of water 52°F.
11	31	SW	1	Dg	[illegible] 48	30	100	- 15	0	Sd	Ss	Good, clear	Dm St		
11	32	SE	1	Dg	---	80	53	- 47	0	Gr	Ab	Good, clear	Dm		Well at Fort Langley School; see analysis

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
11	32	SE	2	Dr	S 5	55	---			Gr	Ab	Good, clear	Dm		Drilled August 1954
11	32	NW	3	Dn	---	30	17	---	0	Sd	F F	Rusty	Dm		
11	33	SW	1	Dg	C 30	63	54	- 57½		Gr	Ab	Good, clear	Dm St		
11	33	SW	2	Dr	S 2	250	14	+		---	---		Dm		
11	33	NW	3	Dr	S 2	360	15			Sd	---	Good, clear	N U	25	Drilled 1909
11	33	SW	4	Dr	S 5	52	47	- 47	---	Gr	Ab	Good, clear			See analysis
12	5	SW	1	Dr	S 2	450	14	+ 8		Sd	Cl	Good, clear	Dm St	52	Temp. of water 52°F. Salty water at 245 ft.
12	6	SE	2	Dr	S 2	347	17	---	325	F sd	Cl	Good, clear	Dm	30	Natural flow.
12	8	NW	1	Dg	W 48	22	20	- 6	---	Gr	F F	Good, clear	Dm St		
13	6	SW	1	Dg	C 36	12	178	- 5	11	Gr	Ab	Good, clear	Dm St		
13	6	SW	2	Dr	S 6	106	139	Surface				Good, clear	Dm	120	Natural flow. Well at Customs Bldg.
13	7	SW	1	Dg	C 36	15	266	- 12		Sd	Ab	Good, clear	Dm		Well at Patricia School
13	8	NW	1	Dr	S 8	---	286	---	---	---	---		D		Drilling discontinued.
13	18	NE	1	Dg	C 36	42	332	- 40		Sd	Ab	Good, clear	Dm St		Sufficient for 2500 poultry.
13	19	NE	1	Br	C 36	29	324	- 18	20	Sd	Hn	Good, clear	Dm		Supplies 12 families at Auto court.
13	19	NE	2	Dg	C 36	47	337	- 35		Sd?	Hn	Good, clear	Dm		Aldergrove School Well, see analyses
13	19	NE	3	Dg	C 36	45	339			Sd	Hn	Good, clear	Dm		Sandpoints driven into bottom of well Aldergrove Town well, supplies 70 families
13	20	NW	1	Dg	C 36	31	331	---	20	Sd	Hn	Good, clear	Dm		Seven sandpoints driven into bottom of well Aldergrove Town well
13	20	SW	2	Dg	C 32	32	328	- 28	32	Sd	Hn	Good, clear	Dm		Water in sand below stony clay
13	29	NW	1	Dr	S --	70	352	---	---	Sd	Hn	Good, clear	Dm		Log incomplete.
13	30	NE	1	Dr	S --	484	358	---	356	See log	P V	Good	Dm		See analysis, well at Naval Station, see log
13	30	SE	2	Dg	C 36	15	349	- 14		Sd	Ab	Good, clear	Dm		
13	32	NW	1	Dg	- 48	43	337	- 41	36	Sd	Hn	Good, clear	Dm		Water in sand below stony clay
14	6	NE	1	Dr	S 4	182	292	- 140	-41	Gr sd	Hn	Iron	Dm		
14	6	NW	2	Dg	C 30	9	328	- 5		Sd	Ab	Good, clear	Dm		
14	7	SW	1	Sp	---	6	332	Surface	---	S t	Sm T	Good, clear	Dm		

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
14	7	NE	2	Sp	---	7	285	surface	---	S t	Sm T	Good, clear	Dm		
14	19	NE	1	Dg	C 30	8	11	---	0	Gr sd	F F	Good, clear	Dm		
14	20	NW	1	Dr	S 2	400	23	+ 18	---		Cl?	Good, clear	Dm St		Natural flow
14	29	SW	1	Dr	---	612	14	+ 29			Cl?	Good, clear	Dm St	200	
14	29	NW	2	Dg	W 48	18	19	- 9	---	Gr	Ab	Iron			4,000 gals. a day
14	30	NE	1	Dr	S 2	510	12	+ 18		Sd	Cl	Good, clear	Dm St	300	Temp. of water 51°F. natural flow.
14	30	NE	2	Dr	S 2	392	14	+ 20		Sd	Cl	Good, clear	Dm St		Natural flow
14	30	NE	3	Dr	S 2	450	12	+ 20		Gr	Cl			900	Natural flow
14	32	SW	1	Dr	S 2	290	20	+ 5		Sd	Cl	Good, clear	Dm St	75	Temp. of water 53°F.

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CONTENTS

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CHAPTER I

INTRODUCTION

This report deals with the ground-water conditions of Matsqui Municipality in the province of British Columbia investigated by officers of the Geological Survey of Canada during the field season of 1955. Geological mapping of the area was carried out under the direction of J.E. Armstrong; the ground-water investigation was supervised and carried out by the writer who was assisted during the field season by J.D. Stothers and P.L. Strack. Grateful acknowledgement is made to all well owners and drillers for their cooperation and willingness to supply information.

The extensive use of groundwater for domestic and municipal supplies and the rapidly expanding search for irrigation water have resulted in the need of an understanding of the ground-water hydrology of Matsqui Municipality.

The ground-water investigation included an inventory of representative wells and springs. More reliable data have been added from logs of private wells and of test holes drilled since 1955. These logs were obtained by the writer at the drilling site or were submitted at a later date by the drillers. Complete records and logs are filed at the Vancouver office, Geological Survey of Canada, and are available to anyone seeking additional ground-water data.

LOCATION AND EXTENT OF AREA

Matsqui Municipality covers an area of about 85 square miles and extends from the International Boundary north to Fraser River and is bounded on the west by Langley Municipality and on the east by Sumas Municipality.

CLIMATE

The climatic conditions of the Fraser Lowland are highly variable and influenced to a large extent by the mountain relief north and east of the region. This influence accounts for a strong increase in precipitation in both a north-south and west-east direction (see Chapman, 1952, pp. 14-15).

The characteristic feature of the region is a heavy winter rainfall and a summer dry period. About two thirds of the average total precipitation of 59 inches occur from October to March. The growing season from April to September, even in wet years, has too little precipitation for the maximum development and yield of crops.

The heavy, sustained rains that occur during October to March replenish the ground-water reservoirs. During this period, apart from run off, little is lost by evaporation and transpiration, the soil and sediments above the water-tables are kept wet and maximum infiltration results.

INDUSTRY

Agriculture is the principal industry of Matsqui Municipality. Vegetable and small fruit production as well as poultry raising are major sources of income. Dairying and the raising of forage crops are carried out chiefly in Matsqui Valley. Other crops include bulbs, cut flowers and nursery stock.

Abbotsford outwash (see map showing surficial deposits) has provided gravel and sand for the construction industry. Glacio-marine clays exposed along the south side of Fraser River in sec. 27, tp. 14 are strip-mined and used as a source of clay in the manufacture of cement.

TOPOGRAPHY AND DRAINAGE

Matsqui Municipality forms a part of Fraser Lowland. The west half of the municipality is part of the Langley Upland, with a rolling surface that rises in places to elevations of more than 400 feet above sea-level. The southeast part, Abbotsford Upland, is triangular shaped with a belt of north-south trending ridges along the east side that rise 75 to 100 feet above the general flat surface of the upland.

Matsqui Valley occupies the northeast part of the municipality and is bounded on the east by Sumas Mountain. This lowland area has a relatively flat floor which lies at elevations of less than 25 feet above sea-level. Dykes along the south bank of Fraser River protect the valley during flood stages of the river. The east part of Glen Valley is included in the northeast corner of Matsqui Municipality. Like Matsqui Valley, Glen valley has a flat floor with sides rising abruptly to elevations of more than 300 feet.

The northwest quarter of the municipality is drained by Nathan Creek, which flows from the upland to the flats of Glen Valley and into Fraser River. McLennan, Downes and Wilbrand creeks, originating in the upland areas surrounding Matsqui Valley, spill out into natural or man-made drainage channels across the floor of the valley.

In the southeast quarter (Abbotsford Upland) of the municipality almost all the rainfall infiltrates the permeable surface deposits. In this area, the surface of the water in the gravel pits as well as in Abbotsford, Laxton and Judson lakes is an expression of the water-table. Ground-water seepage is also responsible for the discharge of Fishtrap Creek which flows south across the International Boundary.

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CHAPTER II

PLEISTOCENE AND RECENT GEOLOGY

TYPES OF DEPOSITS

The entire municipality of Matsqui is underlain by thick deposits of unconsolidated sediments of Pleistocene and Recent ages. In this report the term Pleistocene refers to that epoch in the earth's geological history when large areas of the earth's surface were covered more than once by great glaciers many thousands of feet thick. The epoch is estimated to have started somewhat less than a million years ago. The last glacial age continued in the Matsqui area to within about five to ten thousand years of the present. The term Recent is used in this report to refer to post-Wisconsin time or present non-glacial time.

The deposits formed during the Pleistocene and Recent periods are shown on the table of surficial deposits accompanying this report and consist of clay, silt, sand, gravel, peat, varved clay and silt; stony, clayey silt, silty clay and related till-like mixtures; and till. The terms clay, silt, and sand as used here are based on the diameter of the constituent particles as follows: clay, less than 0.002 mm; silt, 0.002 to 0.05 mm; and sand, 0.05 to 2 mm. The clays and silts are composed chiefly of rock flour produced by mechanical abrasion by glaciers and only to a minor extent of clay minerals formed by chemical decomposition of rocks. The sands are in a large part quartz but contain in addition many feldspar and rock fragments. The clays and silts and mixtures of the two are mainly off-shore marine deposits, and to a much lesser extent, stream and river deposits, both flood-plain and channel. The sands and also the gravels may be glacial outwash deposits or post-glacial stream and river deposits. Outwash consists of the sediments deposited by streams issuing from glaciers.

The stony, clayey silt, silty clay and related till-like mixtures are in a large part glacio-marine and to a lesser extent normal marine deposits that were laid down in the sea during the advance and retreat of an ice-sheet and during the subsequent uplift of the land. The glacio-marine

deposits are marine drift; that is, the stones and part of the fine material were transported by floating ice and the remainder of the fine material was carried by meltwater and sea water. Mechanical analyses of stony clayey silts, and silty clays, show that, exclusive of stones, they comprise about 40 per cent silt, 40 per cent sand and 20 per cent clay.

Glacial till, as used in this report, is a very compact, unsorted mixture of sand, silt, clay and stones deposited directly beneath glacial ice. The only till exposed in Matsqui Municipality is the Sumas till but an older till, the Surrey, has been identified in well records. Mechanical analyses of the fine fraction of representative samples of tills from the lower mainland yielded the following average results: Sumas till, 63 per cent sand, 33 per cent silt and 4 per cent clay; Surrey till, 57 per cent sand, 41 per cent silt and 2 per cent clay.

The unconsolidated sediments in Matsqui Municipality attain a maximum thickness of at least 1,000 feet along the International Boundary and also in Matsqui Valley; whereas on Sumas Mountain such sediments are in the order of a few tens of feet thick.

STRATIGRAPHY AND HISTORICAL GEOLOGY OF PLEISTOCENE AND RECENT DEPOSITS

The table of surficial deposits that accompanies this report shows graphically the complex interrelations and age of the surficial materials. The oldest deposits are shown at the bottom of the table and the youngest at the top. Deposits shown alongside one another indicate that they are of the same general age but were laid down in different environments. Note that the graphic representation illustrates, for example, that Sumas glacial deposits were laid down in part of the area at the same time non-glacial Capilano deposits were laid down elsewhere in the area. A hole drilled in search of water would penetrate the deposits in the order shown from the top of the table to the bottom except where a deposit has been removed by erosion or locally was not deposited.

All ages are relative except in the case of the Capilano. Wood collected at the base of Sumas till and hence part of the Capilano group. was dated as 11,300±300 years. The wood on which the radio-carbon age determination was made was collected from an exposure on Mount Lehman road (sec. 2, tp. 14).

Study of the surficial deposits in Langley and Surrey municipalities west of Matsqui, indicates that the Fraser Lowland area was subjected to four glaciations. The table of surficial deposits included in this report indicates the Sumas glaciation, which was probably valley glaciation, and one major glaciation, the Vashon, which reached ice-sheet proportions. Two pre-Vashon major glaciations were also of ice-sheet proportion and during their maxima were probably 7,500 or more feet thick over the valleys. During each major glaciation the land was depressed relative to the sea, and this lowering of the land surface probably amounted to at least 1,000 feet in the case of Vashon glaciation. At the maximum of Vashon glaciation the ice rested on the sea floor. Surrey till was deposited beneath the ice. During the retreat of the ice, largely by wasting, the ice thinned and floated and glacio-marine Newton Stony clay deposits were laid down. After the Vashon ice melted and as the land rose above the sea, the off-shore marine Cloverdale sediments were laid down.

Huntingdon gravel deposits underlie Whatcom glacio-marine deposits. They appear to be stream deposits, partly in the form of marine deltas, that were laid down following the retreat of Vashon ice but before the advance of Sumas ice.

During post-Vashon time the Sumas ice advanced westward across Matsqui Municipality. In its initial stages this ice-sheet terminated in the sea and deposited glacio-marine Whatcom deposits in front of and beneath the ice. As the land rose, the Sumas glacier was grounded and advanced and retreated across the Whatcom glacio-marine drift, depositing Sumas till and recessional Abbotsford outwash. At one time during retreat, the Sumas ice remained relatively stationary and ice-contact deposits were laid down between the ice front and the Langley Upland.

Meltwater from the grounded Sumas glacier collected in Matsqui Valley and formed a lake in which silt and silty clay were deposited, with minor sand and gravel rimming the lake.

Following the disappearance of the Sumas ice, prevailing westerly winds blowing across the vast expanse of Abbotsford outwash built sand dunes in and south of Abbotsford village.

The Salish deposits relate to the present sea, river and lake levels and are represented by channel and flood-plain deposits along Fraser River and smaller streams. Slopewash deposits as well as peat bogs and swamp deposits are included here.

DISTRIBUTION OF PLEISTOCENE AND RECENT DEPOSITS

The distribution of the Sumas and younger deposits is indicated on the geological map accompanying this paper. The Salish deposits are confined to the lowlands.

Whatcom glacio-marine deposits appear at the surface over much of the upland area and they in turn are underlain by the lithologically similar Newton stony clays except where separated by the Huntingdon gravel. Sumas till occupies a belt of hills that extend across the Abbotsford Upland and continue northwest to border the Langley Upland. Scattered deposits of Sumas till are mapped elsewhere and it is believed that a thin mantle of this till, deposited over much of the area, has become part of the present agricultural soil zone. Abbotsford outwash deposits are widespread over much of the southeast part of the municipality and these deposits represent the materials that were washed and carried by meltwater beyond the margin of the Sumas ice. Ice-contact deposits extend from the International Boundary to Matsqui Valley along the edge of the Langley Upland area that includes most of the west half of the municipality. Glacio-lacustrine deposits are found on the slopes that rim Matsqui Valley and in places are overlain by slopewash and Fraser flood plain deposits.

The Vashon deposits are not exposed in the municipality but have been positively identified in the deep wells drilled at Clearbrook and have been tentatively identified in other holes. Surrey till is believed to be widespread beneath the Whatcom and Newton glacio-marine deposits throughout the municipality.

CHAPTER III

GROUND-WATER GEOLOGY

GENERAL CONDITIONS

Ground water or underground water is the water that supplies springs and wells. Where the supply of surface water has been inadequate, contaminated or entirely lacking, man has dug wells in search of ground-water supplies. In many places ground water in sufficient quantity can be found to meet the demands of agriculture and industry without constructing large, long pipelines or aqueducts to carry water into an area from distant surface sources. The amount of water replenished annually and the amount available in storage in the ground-water reservoirs are, however, important factors to be considered before undertaking programs of ground-water development.

Source

The source of all ground water is precipitation in the form of rain or snow. An inch of rainfall covering a square mile is equivalent to approximately 14,520,000 imperial gallons. The average rainfall for Matsqui Municipality is approximately 59 inches a year, therefore each square mile of the municipality receives some 856,680,000 imperial gallons annually.

Some of the precipitation is carried away by surface run-off and some of it infiltrates the soil zones. Of the latter, part is absorbed by plant roots, part is lost in evaporation and the remainder percolates downward to the ground-water reservoirs. The amount that will infiltrate the soil zone is determined by such factors as temperature, amount and intensity of the precipitation, slope of land surface and the character and texture of the surface deposits.

Occurrence and Movement

Ground water occurs in the voids, interstices or pore spaces of the unconsolidated surface deposits and in fractures and fissures of the bedrock. In the Matsqui Municipality the unconsolidated surface deposits are in most places 1,000 or more feet thick; therefore, only the occurrences and development of the ground water in these deposits is considered. No bedrock wells are known.

Water occurring in gravel, sand or mixtures of gravel and sand, is free to move under the influence of gravity or water-table slopes. Gravels, sands or mixtures of gravel and sand are said to be permeable or pervious, and water contained in them is readily available to supply springs and wells. Clays and silts consists of minute, closely spaced particles and water occurring between these particles is held by molecular attraction and is not free to supply springs or wells. Clay, silt, and material with a high proportion of clay or silt are, for all practical purposes, impervious.

Ground water moves from recharge to discharge areas at rates measured in feet per day to feet per year. Recharge areas are those areas where the surface deposits are permeable and allow maximum infiltration of precipitation. Discharge occurs naturally, at the surface, by springs and seeps, and artificially by means of wells.

The Water-table

The water-table is defined as the upper surface of the zone saturated by free ground water, and is the level at which water will stand in a well dug into permeable materials such as the Abbotsford outwash. The water-table is generally a sloping surface, having a gradient in the direction of ground-water movement; it is not stationary but fluctuates with variations in amounts of recharge and discharge. In Matsqui Municipality the water-tables are lowered as much as 5 feet during the period April to October but rebound annually owing to the heavier precipitation occurring during the months of November to March.

GROUND-WATER RESERVOIRS

Ground-water reservoirs or aquifers are saturated zones of permeable material from which ground water can be obtained by pumping or natural flow. The complex Pleistocene geology of Matsqui Municipality has resulted in the formation of three main types of ground-water reservoirs, namely, perched, free, and confined ground water.

Perched ground-water occurs in a saturated zone separated from the main body of ground water by impervious strata. In Matsqui Municipality it occurs in Sumas till deposits that overlie Whatcom glacio-marine deposits. In parts of Langley Upland where remnants of sandy Sumas till are thin, water stored under perched conditions is discharged naturally by springs in volumes sufficient to supply several farms. Perched ground-water reservoirs also exist in places where Fraser flood plain deposits are channeled.

Free ground-water reservoirs exist in areas of Abbotsford outwash, Huntingdon gravel, and in the slopewash deposits. The sand and gravel in such areas is porous and allows for maximum infiltration, the water percolating downward under the influence of gravity to the zone of saturation. The water-table comes to the surface at Abbotsford, Laxtone and Judson Lakes and is also exposed in gravel pits in the Abbotsford outwash.

The water in confined ground-water reservoirs does not move under the influence of water-table slopes but is confined by an overlying less permeable or impervious stratum and hence movement is restricted vertically but not necessarily horizontally. In areas where Whatcom glacio-marine clays are present at the surface penetrate the relatively impervious clays and reach, in most places, Huntingdon gravel and sand, which there constitute a confined aquifer. Water in confined aquifers is under pressure and rises in wells to a point above the top of the aquifer and under some conditions overflows at ground level. Wells in which the water is under pressure but does not rise to the land surface and overflow are

non-flowing artesian wells, whereas those in which the water is under sufficient pressure to cause it to rise to ground level and overflow. The height to which the water rises in either flowing or non-flowing artesian wells is a pressure surface, called the peizometric surface. The peizometric surface is not analagous to the water-table that exists in free unconfined ground-water reservoirs.

Confined aquifers underlying less permeable sediments in Glen Valley yield flowing artesian water. The writer believes that similar hydrologic conditions exist in Matsqui Valley in confined aquifers below 500 or more feet of less permeable silt and clay.

CHAPTER IV

TYPES OF WELLS AND WELL DEVELOPMENT

The complete development of wells is the objective of modern well drilling. The purpose of this section is to draw the attention of engineers, drillers, and prospective well owners in Matsqui Municipality to certain fundamental principles of ground-water recovery and well use so that they may know the problems that exist and the corrective measures that are employed elsewhere. Additional information may be obtained from technical journals and from some of the references listed on page of this report.

A well is constructed to tap the ground-water reservoirs to obtain, as economically as possible, the required amount of ground water. Failure to obtain an adequate supply depends, in some cases, not only on characteristics inherent in the formation penetrated, but also on the type of well and the construction or development methods used.

TYPES OF WELLS

Dug, bored, driven and drilled wells are the four main types and each has its special use and function under certain conditions. The factors that determine the types of well are: depth to water, characteristics of the sediments from ground surface to the water, characteristics of the water-bearing sediments, the static level of the ground water, the amount of water required, and the investment that the prospective owner is prepared to make.

Dug wells are of limited usefulness in much of Matsqui Municipality because the available ground water exists in confined aquifers at greater depths than it is advisable to dig wells by hand. Dug wells are a common means of recovering ground water from part of the Abbotsford outwash free ground-water reservoir. In the Langley Upland wells dug into Whatcom glacio-marine deposits are easy to dig but their yield fluctuates seasonally. Most of the water is collected from surface run-off and therefore these wells act chiefly as cisterns.

Bored wells, sunk by means of a hand or power-driven auger, are not widely used but where the stony clays are less than 50 feet thick, power-driven bucket-type augers could be used to penetrate to the underlying water-bearing sediments. Where the underlying water-bearing sediments include running sands or quicksand, boring operations may have to cease. However, at this point, at the bottom of the bored well, a sandpoint driven into the fine sands may yield enough water to make the well a producer.

Driven wells are constructed by driving a casing tipped with a drive point or sandpoint. Although an advantage over a dug well, driven wells are limited in their use to areas of outwash where the sands are medium to coarse grained. On uplands, driving sandpoints through the marine clays to underlying sands is not recommended because of stones encountered in the clays. In Matsqui Valley sandpoints can be used in the coarser grained Fraser flood plain and channel deposits, but the underlying Cloverdale sediments are too fine to give up their water to pumps attached to sandpoints.

Drilled wells are the most effective for development of ground water in a large part of Matsqui Municipality. They may be finished as open-end, screened, or gravel-packed wells, all of which are lined with a casing commonly 6 inches in diameter. Cable tool drilling rigs are in common use but in Glen Valley and in Matsqui Valley wells may be successfully drilled by a jetting or rotary rig. In jetting a well the casing, less than 2 inches in diameter, is forced down during the drilling as the sands and sediments are washed up by means of water forced through the drill stem. These wells may penetrate to depths of 700 feet.

An open-end well allows water to enter through the open end of the casing. No screen or other device is used to keep sand from entering the well and hence failures resulting from plugging with sand are common especially when over-pumping is carried out. All wells drilled by the jetting method are open-end wells.

Screened wells are those in which a screen or strainer is used on the lower end of the casing to permit maximum development of the aquifer. After the screen or strainer has been placed in position, development procedures are carried out to remove the fine material surrounding the screen. The removal of the fine material through the screen leaves coarser material naturally graded and packed around the screen.

To develop an efficient well in an aquifer made up entirely of fine material, a pack of gravel or sand may be placed around the outside of the screen. When this development is anticipated the initial well is drilled with a larger diameter than the final well to allow for the introduction of the gravel and sand pack.

WELL DEVELOPMENT

Wells are developed by means of post-drilling treatments to establish the maximum yield of usable water. To improve the yield, the methods commonly used include surging, over-pumping, backwashing and treatment with acids, or other chemicals. All methods, except the acid treatment, are designed primarily to wash fine sand, silt, and clay from the water-bearing formation immediately surrounding the well screen.

Surging is the method most commonly used where the water-bearing materials contain sand and fine gravel mixed with silt but over-pumping is a satisfactory procedure where coarse sand and gravel make up the aquifer. The surging method involves the use of a surge plunger which is operated up and down in the well casing for the purpose of alternately creating an inward and outward movement of water through the screen. The repeated surging action eventually moves the fine sand up to and through the screen from where it is removed by bailing. After the fine particles have been drawn into the well and removed, the coarser particles left on the outside of the screen have created a new mixture of particles having a high porosity and permeability. The treatment known as backwashing includes operating the pump at its maximum capacity and periodically stopping the pumping

and releasing the foot-check valve. The water then rushes back into the well and agitates the sediments around the screen. During pumping the water in a well drops from the static level to the pumping level, and this drop measured in feet is known as the drawdown. As the water in a well drops to the pumping level, the attitude of the water level in the aquifer around the well becomes that of an inverted cone. The size and shape of this cone, known as the cone of depression, is controlled by the rate of pumping, the permeability or water yielding capacity of the water-bearing material and the slope of the water-table near the well. For example, if the pumping rate is high and the water-bearing material is coarse, then the cone of depression will affect a large area of the water-table but the height of the inverted cone will be relatively small. Under these conditions many neighbouring wells may be affected. When the pumping is stopped, the dewatered area normally fills up again.

The specific capacity or yield per foot of drawdown of a well should be determined especially when large flows are demanded. With the advent of the practice of irrigation to produce maximum crop yield it is necessary that wells drilled for this purpose be developed to maximum capacity as they will be subjected to long-term pumping. Most wells drilled for domestic or farm needs do not require extensive development as the initial yield meets the water requirements.

CHAPTER V

GROUND-WATER GEOLOGY OF MATSQUI MUNICIPALITY

The topographic units described below are merely convenient subdivisions for the discussion of the ground-water geology of Matsqui Municipality. The aquifers or ground-water reservoirs are those within 400 feet of the ground surface. These aquifers will yield a constant supply of potable water to properly developed drilled, driven, or dug wells.

LANGLEY UPLAND

Water Reservoirs

Langley Upland includes the greater part of the west and northwest part of the municipality. In the north part of this upland, Sumas till (6) in places mantles Whatcom glacio-marine deposits (5). Ground-water reservoirs in the Sumas till are perched and the free ground-water table slopes east causing springs to issue along the thin boundaries of the till.

Huntingdon gravel deposits (4) that underlie Whatcom glacio-marine deposits are a source of confined ground water. In places where the Huntingdon gravels are thin, lacking, or grade into fine sand, water in sufficient quantities is not available. At such places, however, permeable materials at greater depth below Newton stony clay and Surrey till are a source of confined ground water.

Langley Upland is bounded on the south by Abbotsford outwash, ice-contact deposits (8b) consisting of gravel, sand, and lenses of till, and glacio-marine clayey silt. The lenses of sand and gravel within these ice-contact deposits are discontinuous but favourable aquifers. North of the belt of ice-contact deposits and extending north to the Trans-Canada Highway, the Abbotsford outwash deposits (8a) contain free ground-water reservoirs.

Ground-water Recharge and Discharge

The Whatcom glacio-marine deposits are slightly permeable and allow limited percolation but where these deposits are at the surface the greater part of the precipitation is lost in run-off. Areas of Sumas till and Abbotsford outwash are recharged directly by precipitation and the water is stored under perched or free ground-water conditions.

Ground water is discharged naturally by springs at the margins of the Sumas till and at places from the ice-contact deposits where lenses of permeable sand and gravel overlie impermeable clays.

Recovery of Ground Water

Ground water is recovered by dug or drilled wells and springs. Huntingdon gravel deposits constitute the principal confined aquifer in that part of Langley Upland included in township 14. The Whatcom glacio-marine deposits are in places as much as 300 feet thick and test holes, 100 feet to 250 feet deep, on many farms have not penetrated these deposits to the underlying aquifer, resulting in discouraging results. Wells that have bottomed these deposits have invariably been successful. Some examples are cited below.

In SW. 1/4 sec. 10 a successful well drilled to a depth of 205 feet penetrated the stony clay to reach a water-bearing sand.. A well drilled on the hillside in NE. 1/4 sec. 15, tp. 14 penetrated 135 feet of Whatcom glacio-marine deposits, 20 feet of Huntingdon sand, 70 feet of Newton stony clay and encountered water-bearing gravel at 225 feet. The water in this confined aquifer rises in the well to a point 185 feet below the land surface, or 40 feet above the top of the aquifer. The 20 feet of Huntingdon deposits were either dry along this hillside or too fine-grained to give up their contained water when penetrated by the drill.

Springs along the margin of the Sumas till in the Mount Lehman district, especially in sec. 12 and 13, tp. 14, yield an abundance of water. One spring, in SW. 1/4 secs. 13 yields 80 gallons per minute and supplies seven farms. The community of Mount Lehman and 14 nearby farms are supplied with water by pipeline from a spring in NE. 1/4 sec. 12. Along the western limit of the Sumas till, wells drilled 33, 53 and 41 feet, yield abundant water in SE. 1/4 sec. 14, SE. 1/4 sec. 4, and NE. 1/4 sec. 11, respectively.

The Whatcom glacio-marine deposits are for all practical purposes impervious. Large-diameter wells dug into these clays fill with water during the wet seasons but fail during the summer months. The writer suggests that dugouts could be built in these deposits on those farms needing abundant water for beef and dairy cattle.

The south half of Langley Upland is included in township 13. Along the Trans-Canada Highway wells are drilled to the Huntingdon gravel deposits that underlie 8 to 200 feet of Whatcom glacio-marine deposits. At the Aberdeen school, a well penetrated 133 feet of Whatcom deposits to encounter water-bearing Huntingdon gravel deposits. Sufficient water to supply the school, 10 to 15 gallons a minute, is pumped from the top 6 feet of this aquifer. In places, however, the Huntingdon gravel deposits may be thin or lacking. This condition was found in SW. 1/4 sec. 24 where two test holes were drilled 230 and 258 feet. Only a thin seam of sand, representing the Huntingdon deposits, was found in both test holes at approximately 130 feet.

Discontinuous lenses of sand or gravel, forming part of the Sumas ice-contact deposits (8b), yield water to wells and springs. These supplies, commonly sufficient, are obtained from aquifers of only local extent which probably do not contain water in sufficient volume for irrigation.

Wells dug or drilled 50 feet or less obtain sufficient supplies from the free ground-water reservoir included in the Abbotsford gravel deposits north and west of the belt of ice-contact deposits.

ABBOTSFORD UPLAND

Water Reservoirs

Abbotsford Upland includes an area of approximately 20 square miles that extends south and west from Abbotsford to the International Boundary. This area is underlain by Abbotsford outwash sand and gravel deposits (8a) that vary in thickness from 30 to 100 feet. These deposits constitute a free ground-water reservoir with a water-table 10 to 50 feet below the land surface. The water-table in the Abbotsford outwash slopes to the southwest and during the driest summers drops not more than 5 feet under the present rate of discharge.

Sumas till (6) mantles the Abbotsford outwash along the east side of this upland but in this area the underlying outwash gravel constitutes the principal aquifer.

Huntingdon gravel is also an important aquifer in this upland and in places underlies the Abbotsford outwash and elsewhere is separated from the outwash by Sumas till or Sumas till and Whatcom glacio-marine deposits.

Ground-water Recharge and Discharge

Nearly all the precipitation in this area penetrates the permeable sand and gravel. Evaporation and transpiration account for partial loss of the precipitation that enters the soil zone. Total annual recharge has been estimated by the writer to be at least 5 billion gallons, which provides a safe daily yield of 13 million gallons to supply the required needs.

Ground water is discharged naturally through Fishtrap Creek and springs along the east side of this upland in the adjacent municipality.

Recovery of Ground Water

Water is obtained from wells and large volumes could also be pumped, especially for irrigation use, from gravel pits or from Abbotsford, Laxton and Judson lakes. Wells on the west side of the upland are dug or drilled to depths of 30 to 50 feet. The depth to the water-table increases towards the east and along the east side of the

upland wells are 100 to 150 feet deep. Three of the more important wells that together could produce more than a million gallons of water a day are described below.

In SE. 1/4 sec. 1, tp. 13, a well 42 feet deep, 8 inches in diameter was drilled at a central point on the farm. The water-table lies within 17 feet of the ground surface. A screen 10 feet long was placed in the bottom of this well and the casing adjusted as required. Surging operations followed at intervals of 30, 60 and 90 minutes until all fine material capable of passing through the screen was removed and bailed out of the well. When the surging operation was completed, the well was test pumped at a rate of 250 gallons a minute. The drawdown, that is, the distance the water dropped from its static level to its pumping level measured 9 feet with rapid recovery once pumping operations ceased.

In SW. 1/4 sec. 16, tp. 16, a well 8 inches in diameter penetrated 88 feet of windblown sands, Sumas till and glacio-marine deposits to reach underlying Huntingdon gravels and drilling continued to a depth of 132 feet. A screen, 17 feet in length was placed in the well opposite the coarser water-bearing materials at a depth of 111 to 128 feet. Development procedures included surging with a loose surge block followed by pump surging. The pump test over a period of 7 hours included pumping at an initial rate of 100 gallons a minute. A drawdown of 12 feet was observed with recovery in 2 seconds upon cessation of the pumping.

An 8-inch diameter well, 80 feet deep was drilled in NW. 1/4 sec. 5, tp. 16. Eighty feet of outwash gravel was penetrated and the water-table was encountered at 50 feet. The coarse outwash required no further development than cleaning out the well by bailing and light surging. The well was test pumped at a rate of 290 gallons a minute, and therefore supplies sufficient water to irrigate approximately 40 acres in this area.

MATSQUI VALLEY

Water Reservoirs

Matsqui Valley, an area of about 25 square miles in the northeast part of Matsqui Municipality, was formerly occupied by a glacial lake. Silt, clay and sands were deposited in the lake which later drained and the area became successively a meander of the Fraser River and later a back swamp in which alluvial silt, clay, sand ridges and, in places, peat were deposited. The position and extent of confined aquifers in the valley have not been determined, but the geological evidence is such that confined ground-water reservoirs are expected to exist in coarser sediments that underlie the clay, silt and fine sand that fill the valley to depths of possibly 500 feet or more.

In places where the Fraser flood-plain deposits (9) are channeled, ridges of sand store ground water under perched condtions. Precipitation, springs along the valley sides, and creeks that cross the valley floor contribute water to recharge the perched ground-water reservoirs. Water collected in the fine sands and silts penetrates downward to recharge the coarser sediments at depth. Recharge from the Fraser River may be effective during periods when the river is at flood or high-water stage.

Recovery of Ground Water

Ground water is recovered from the perched reservoirs by means of sandpoints and shallow dug wells.

A well drilled in NE. 1/4 sec. 33, tp. 16 penetrated 50 feet of silty clay and drilling continued to a depth of 72 feet into fine-grained sands. A screen was placed in the well opposite the water-bearing sands at a depth of 62 to 72 feet.

Development of this aquifer proved difficult because of the uniform fine-grained sand composition but the well produces 12 gallons per minute. The water is of poor quality and carries fine sand during pumping. No other wells have been drilled in this valley and hence the position and extent of confined aquifers indicated above are conjectural and based on geological interpretation and results of test drilling under like

geological environments in valleys in Langley and Sumas municipalities.

GLEN VALLEY

The greater part of Glen Valley is in Langley municipality. That part included in Matsqui Municipality has a relatively flat floor covered with recent flood-plain deposits of Fraser River and in places peat. Perched ground-water bodies are present in terraced sands and gravels at the base of the valley walls as well as in coarser sediments of the surface Fraser flood-plain deposits. Shallow wells and sandpoints are used to recover the ground water from these reservoirs.

Along the outer edge of Glen Valley, bordering Fraser River, drilled wells as much as 150 feet deep encounter confined aquifers, underlying Cloverdale sediments, in which the water is under sufficient pressure to rise to the surface and flow.

SUMAS MOUNTAIN

Sumas Mountain is in general mantled with unconsolidated deposits. Only that part of Sumas Mountain included in township 16 was investigated and there the unconsolidated deposits are, in places, as much as 200 feet thick. Abbotsford outwash gravels from a few inches to more than 75 feet thick overlie till. In places the gravel is thick enough to store water under perched ground-water conditions; this water is yielded to shallow dug wells. Although nearly impermeable, the till does yield small amounts of water to large-diameter dug wells. Some successful wells penetrate the till and obtain water from gravel beneath it.

At the foot of Sumas Mountain, south of Clayburn village in NE. 1/4 sec. 26, tp. 16, slopewash deposits (10) overlying possible glacio-lacustrine deposits (7) and Abbotsford outwash (6a) constitute a free ground-water reservoir. This reservoir is recharged by a creek that carries run-off and ground-water discharge from the upland mountainous area. The writer believes that properly developed wells tapping this aquifer would yield at least 100 gallons a minute. Elsewhere at the base of Sumas Mountain, extending from Clayburn village to Abbotsford, slopewash deposits (10) are favourable areas that warrant test drilling in search of potential water supplies for industry or for other uses where large volumes are required.

USE OF GROUND WATER

Most of the wells in Matsqui Municipality supply water domestic and farm use; many are not required to yield more than 500 gallons a day.

Ground water supplies 400 domestic and 6 industrial users in the Clearbrook area. The principal aquifer at a depth of 90 to 100 feet yields in the order of 60 gallons a minute.

A gravel-packed well at Abbotsford airport developed an aquifer at a depth of 33 feet 6 inches to 38 feet 10 inches. Pumping tests carried out on this well in August 1943 indicated a 12 feet 6 inch drawdown pumping at a rate of 158 gallons a minute, and a 17 feet 6 inch drawdown when pumping at a rate of 219 gallons a minute. Static level in the well is 5 feet.

Three wells have been drilled and developed to supply ground water for irrigation. The drilling and development of these wells has already been discussed. In order to carry out average irrigation practices in Matsqui Municipality, agriculturists suggest that irrigation wells be required to yield about 5 gallons of water per minute per acre under irrigation. Therefore, a well yielding 200 gallons a minute would irrigate a 40-acre farm.

Abbotsford Lake is the source of springs that presently supply the village of Abbotsford.

Surface water in Poignant and Downes creeks is dammed and distributed through 14 miles of pipeline to service 230 domestic and 6 commercial users in Matsqui Valley.

CONCLUSIONS AND RECOMMENDATIONS

Most of the ground water pumped from wells in Matsqui Municipality comes from Aquifers of permeable sand and gravel. Channel, flood-plain and outwash deposits function as recharge areas and storage reservoirs. These reservoirs constitute perched or free ground-water aquifers that yield volumes of from 100 to 300 gallons a minute from individual wells. Elsewhere permeable materials underlying glacio-marine deposits and/or till store ground water under confined conditions and yields of 15 to 50 or more gallons a minute are reported from wells that penetrate to such confined aquifers.

Ground water sufficient to supply the more populated centres is available in the Abbotsford outwash, Huntingdon gravel or slopewash deposits. The most favourable areas for the development of large supplies are those in which Abbotsford outwash or Huntingdon gravel has a maximum thickness, or is overlain by slopewash deposits.

The position and extent of confined aquifers underlying glacio-lacustrine deposits and Cloverdale sediments in Matsqui Valley have not been outlined. It is, however, reasonable to consider test drilling in this area when prospecting for large volumes of ground water.

The average temperature of the ground water is 49°F. It has a favourable quality, is obtainable at reasonable depth where it is needed, and the writer believes it would be found in volumes sufficient to meet the demands of the municipality.

When prospecting for ground water in large quantities, drilling programs should include preliminary test holes in order to determine the conditions existing in the materials to be penetrated and therefore to determine the type of final well and construction methods to be used.

CHAPTER VI

QUALITY OF WATER

Water falling as rain is almost pure. As it penetrates the soils and unconsolidated surface deposits mineral constituents are dissolved and the amount and kind of dissolved mineral constituents determine the water's hardness and other chemical characteristics.

In general, ground water in Matsqui Municipality is low in dissolved materials and is satisfactory for most industrial uses. An analytical report on twenty samples analysed by the Mines Branch, Department of Mines and Technical Surveys, Ottawa, is included in this chapter.

The ground water recovered from those confined aquifers below the glacio-marine deposits is characteristically alkaline with an average pH value of 8 and the concentration of sodium and bicarbonate is higher than that found in water from the perched and free ground-water reservoirs. Chloride salts are readily soluble and practically all ground water contains a certain amount of chloride. In all but four samples analysed the chloride concentration was less than 6 parts per million. The four samples with chloride concentrations of 31.9, 43.0, 48.1, and 86.3 parts per million probably represent ground water from permeable sediments below Whatcom glacio-marine deposits and Newton stony clays. However, the recommended limit of chloride in drinking water is 250 parts per million and for irrigation 355 parts per million.

The soap-consuming property of water is called hardness. Hardnesses have been classified by Thomas (1953) as follows:

hardness of 1 to 60 ppm. as $CaCO_3$ - soft water
hardness of 61 to 120 ppm. as $CaCO_3$ - med. - hard water
hardness of 121 to 180 ppm. as $CaCO_3$ - hard water
hardness of more than 180 ppm. as $CaCO_3$ - very hard water

Of the twenty samples included in the table of analyses, thirteen are in the class of soft water, six are medium to hard and one is hard water.

No analyses were made to determine the parts per million of iron. The concentration of iron is commonly low and where present is

within limits that can be removed favourably if the water is to be used for industry. Iron remains in solution and the water is clear until exposed to the oxygen in the air whereupon the iron is oxidized and precipitated. This precipitate causes the brownish or reddish stains that occur on porcelain fixtures, laundry and other materials with which the water comes in contact.

The quality of the water was reported by the well owners, with few exceptions, as being clear and soft.

ANALYSES OF WELL WATERS FROM MATSQUI MUNICIPALITY, BRITISH COLUMBIA
(All figures are in parts per million)

Location	Owner	Sum of constituents	SiO_2 (col)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	Hardness as $CaCO_3$ Total	CO_3	Non-CO_3
NW.15,tp.13	A. Matschke	130.1	19.0	22.5	5.9	10.5	1.9	115.0	6.5	3.2	4.0	80.4	80.4	0.0
NE.19,tp.13	Aldergrove school	148.1	12.5	17.7	4.4	26.6	4.9	146.0	6.9	1.4	1.6	62.3	62.3	0.0
NE.21,tp.13	Aberdeen school	75.6	19.0	12.8	2.8	4.3	0.7	59.6	2.9	1.1	2.4	43.5	43.5	0.0
NW.21,tp.13	C. Newton	125.0	13.0	17.3	6.5	15.8	3.0	120.0	9.3	0.8	0.2	69.8	69.8	0.0
NW.24,tp.13	C.W. Taylor	358.0	19.0	4.6	3.9	129.0	4.7	305.0	0.0	43.0	0.4	27.5	27.5	0.0
NW.25,tp.13	L. Higginson	282.7	17.0	17.6	6.1	75.2	3.4	178.0	25.8	48.1	1.6	69.0	69.0	0.0
SE.26,tp.13	P.J. Unger	329.0	20.0	4.2	3.0	122.0	4.4	348.0	2.1	1.9	0.4	22.8	22.8	0.0
SW.10,tp.14	J.G. Friesen	402.4	28.0	3.3	2.6	150.0	5.4	382.0	11.5	6.5	1.6	18.9	18.9	0.0
NE.11,tp.14	J.R. Friesen	78.7	12.0	9.6	3.1	10.2	1.2	61.7	3.6	0.8	8.0	36.7	36.7	0.0
SE.14,tp.14	J. Simpson	164.5	18.0	25.7	12.4	11.2	3.2	150.0	13.6	1.2	0.8	115.0	115.0	0.0
NE.15,tp.14	J.J. Froese	267.0	15.0	5.3	5.3	84.2	7.4	197.0	20.0	31.9	0.6	35.0	35.0	0.0

Location	Owner	Sum of constituents	SiO_2 (col)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	Hardness as $CaCO_3$ Total	CO_3	Non-CO_3
NE.5,tp.16	South Poplar school	97.1	19.0	17.3	3.7	4.4	0.9	65.0	3.9	4.1	12.0	58.4	53.3	5.1
SE.7,tp.16	J.H. Willms	60.4	14.0	10.9	1.6	3.3	0.5	36.2	1.0	2.1	10.0	33.8	29.7	4.1
NW.9,tp.16	[illegible]. Ratzloff	84.5	20.0	13.6	2.7	4.6	0.7	51.0	5.1	.7	10.0	45.0	41.8	3.2
SE.19,tp.16	Clearbrook Community Well No. 1	73.3	9.9	12.9	2.4	5.0	1.2	60.3	3.8	5.7	0.6	42.1	42.1	0.0
SW.21,tp.16	[illegible]SA Motors	89.5	19.0	15.8	4.5	4.1	1.1	66.3	6.6	3.0	2.4	57.9	54.4	3.5
NE.29,tp.16	Val Krivoskein	103.1	22.0	17.1	5.6	6.2	1.3	85.6	5.5	2.4	1.2	63.6	63.6	0.0
SE.29,tp.16	H.D. Falls	47.6	19.0	8.7	0.6	5.9	1.8	35.5	5.6	1.6	4.0	24.2	24.2	0.0
NW.29,tp.16	Clearbrook elementary school	211.5	31.0	48.4	11.2	6.8	2.9	221.0	1.0	0.8	0.6	167.0	167.0	0.0
SE.30,tp.16	[illegible].F. Thompson	474.2	27.0	5.4	4.0	164.0	4.8	272.0	42.3	86.3	6.0	29.9	29.9	0.0

COMPILATION OF WELL DATA

The following information and abbreviations pertain to the well records of Matsqui Municipality.

Description of well

Type of well

Dr - drilled, well made by standard drilling rig

Dn - driven (sandpoint)

Dg - dug or hand augered

Sp - spring

Th - test hole, commonly drilled, not developed and completed as a water well

Collar elevation

The elevations are with reference to mean sea-level, and are believed accurate to within 5 feet.

Static level

The static level is the level of the water with respect to the ground level at the collar of the well. Where the level is posititve the water rises above the ground and the well is a flowing artesian well.

Principal aquifers

Depth to top

The depths are the reported depths to the top of the main water-bearing deposits, and are believed to be accurate within 5 feet.

Character of material

The character of the material is that observed by the writer or that reported and believed reliable.

Sd - sand

Gr - gravel

F - fine

Formation

Ab - Abbotsford

Hn - Huntingdon

ST - Sumas Till

GL - Glacio-lacustrine deposits

Water

Use

Dm - domestic

Ir - irrigation

St - stock

Mn - municipal

Yield Gals/hr. imperial gallons per hour.

g.p.m. (imperial) gallons per minute.

Not all the yields reported were measured by the writer; some were reported by the well owners and believed reliable.

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

Location			Well No.	Description of Well					Principal Aquifers		Water	Yield		Remarks
Tp	Sec.	¼		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	1	SE	1	Dr	8	42	170	-17	0	Sd gr	Ab	Ir	—	Well screen placed at 32 to 42 ft; developed well yields 250 gals. a minute; drawdown 9 ft.
13	1	NE	2	Dg	–	25	172	-15	0	Sd gr	Ab	Dm	—	
13	2	NE	1	Dg	–	10	162	—	0	Sd gr	Ab	Dm St	—	Three dug wells, each 10 ft. deep, supply water for 20,000 poultry.
13	3	SE	1	Dg	–	22	145	-10	0	Sd gr	Ab	Dm	—	
13	3	NW	2	Dr	4	105	262	-75	100	Gr	—	Dm St	—	Water in a lens of gravel in ice-contact deposits (8b); supplies approximately 1500 gals. daily.
13	4	SW	1	Dg	36	12	139	-4	0	Sd gr	Ab	Dm St	—	
13	8	SE	1	Dr	4	89	302	-49	70	Sd	Hn	Dm St	—	40 ft. gravel and 30 ft. clay above aquifer.
13	9	SE	1	Dr	4	70	241	-48	—	—	—	Dm St	—	
13	10	SE	1	Dr	—	79	155	—	—	—	—	Dm	—	Well at Peardonville school
13	10	NE	2	Dr	4	109	336	-69	—	Sd	—	Dm St	—	Supplies three farms

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION			WELL NO.	DESCRIPTION OF WELL						PRINCIPAL AQUIFERS		WATER YIELD		REMARKS
Tp	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar Elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of Material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	11	NW	1	Dr	4	130	337	--	--	Sd	--	Dm St	--	Bottom 40 ft. believed to be now filled with fine sand.
13	12	NW	1	Dr	8	38	--	- 1	18	Sd	Ab	Dm	--	Well at Abbotsford airport; yields 158g.p.m.
13	13	NW	1	Dg	20	25	172	-20	0	Sd gr	Ab	Dm St	--	
13	13	NE	2	Dg	--	25	182	-22	0	Sd gr	Ab	Dm	--	Penetrated 24 ft. sand and gravel and 1 ft. stony clay.
13	15	SW	1	Dr	4	69	361	--	68	Sd	Hn	Dm St	275	Supplies five homes
13	15	NW	2	Dr	4	77	336	-47	75	Sd	Hn	Dm St	500	Sample collected
13	15	NW	3	Dr	4	67	?	-20	45	Sd gr	Hn	Dm	--	Penetrated 45 ft. clay and 22 ft. sand and gravel.
13	16	SW	1	Dr	4	86	363	-44	63,86	Sd gr	Hn	Dm	--	
13	16	SW	2	Dr	4	112	390	-70	86,101	Sd	--	Dm	700	
13	17	SE	1	Dr	4	85	369	-50	75	Sd	Hn	Dm St	--	
13	20	NE	1	Dg	36	24	359	-21	--	Sd	Ab	Dm	--	Supply failed in 1951.

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION			WELL NO.	DESCRIPTION OF WELL				PRINCIPAL AQUIFERS		WATER	YIELD			REMARKS
Tp	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	21	NW	1	Dr	4	81	372	-61	78	Sd gr	Hn	Dm	—	Well at Blue Star Motel
13	21	NW	2	Dr	6	99	389	-79	89	Sd	Hn	Dm	—	See chemical analysis
13	21	NE	3	Dr	5	139	420	-127	133	Sd	Hn	Dm	—	See chemical analysis. Well at Aberdeen school.
13	23	NE	1	Dr	4	118	287	-60	—	Sd gr	Hn	Dm Ir	—	Well at Davidson's Nursery
13	23	NE	2	Dr	4	136	301	—	—	Sd gr	Hn	Dm	—	Supplies four houses
13	23	SW	3	TH	6	225	344	—	90	F Sd	—	—	—	Penetrated sand from 70 to 123 ft. and stony clay from 123 to 225 ft. Some water at 90 ft.
13	23	SW	4	Dr	6	360	369	-80?	159	Sd	?	—	—	Penetrated water-bearing sand 159-161 ft., and marine stony clay from 161-360 ft.
13	23	NW	5	Dr	4	86	348	-52	—	Sd	Hn	Dm St	—	
13	23	NW	6	Dr	6	72	360	-57	61	Sd	Hn	Dm	360	Penetrated glacio-marine deposits for 61 ft. and fine to coarse sand from 61 to 72 ft.
13	24	SE	1	Dr	6	16	197	- 2	—	Gr	Ab	Dm	—	

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION			WELL NO.	DESCRIPTION OF WELL				PRINCIPAL AQUIFERS			WATER	YIELD		REMARKS
Tp.	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	24	SW	2	Dr	4	198	260	-20	100, 198	Sd	Hn	Dm	—	On pumping, water carries fine sand; settling tanks are recommended.
13	24	SW	3	TH	—	258	273	—	—	—	—	—	—	Drilled a second test hole 230 ft.; penetrated glacio-marine deposits 60 to 200 ft. Some water at 30 ft. in gravel.
13	24	NW	4	Dr	5	220	306	-43	200	Sd	Hn	Dm St	1,000	See chemical analysis
13	25	NW	1	Dr	4	193	250	-128	190	Gr	Hn	Dm St	400	See chemical analysis
13	25	NW	2	Dr	4	256	280	-139	250	F Sd	Hn	Dm St	—	
13	26	SE	1	Dr	4	129	331	-59	129	Sd	Hn	Dm	—	See chemical analysis
13	26	NW	2	Dr	4	148	335	-63	145	Sd gr	Hn	Dm		
13	27	SE	1	Dr	6	109	400	-90	89	Sd	Hn	Dm St	—	
13	29	NE	1	Dr	4	55	348	-44	52	Gr	Hn	Dm St	360	
13	29	SE	2	Dr	4	83	372	—	80	Gr	Hn	Dm St	—	

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION		WELL NO.		DESCRIPTION OF WELL				PRINCIPAL AQUIFERS		WATER	YIELD		REMARKS	
Tp.	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	33	NE	1	Dr	4	277	360	-170	—	—	—	—	—	Well drilled in 1948; never used.
13	33	SW	2	Dr	4	80	377	—	78	Sd	Hn	Dm St	—	Reported as hard water
13	34	NW	1	Dr	6	134	380	-118	126	Gr	Hn	Dm St	250	
13	35	SE	1	Sp	36	7	325	0	—	—	ST	Dm	—	Spring supplies school. Temp. of water 51°F.
13	36	NE	1	Sp	—	—	94	0	—	—	GL	Dm St	115	
13	36	NE	2	Sp	—	—	108	0	—	—	GL	Dm St	300	
14	1	NW	1	Dr	4	100	296	-85	—	Gr	Hn	Dm St	—	
14	1	NW	2	Dg	30	51	266	-44	6	Gr	Hn	Dm St	—	Penetrated 6 feet Sumas till and 45 ft. of gravel.
14	4	NE	1	Dr	4	75	318	—	—	Sd	Hn	Dm	—	
14	4	SE	2	Dr	5	33	353	—	30	Gr	Hn	Dm	—	Water in gravel below Sumas till-like material
14	5	SE	1	Dr	6	312	330	-215	310?	Sd	Hn	Dm	—	

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION		WELL NO.		DESCRIPTION OF WELL				PRINCIPAL AQUIFERS			WATER	YIELD		REMARKS
Tp.	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
14	9	SE	1	TH	6	243	384	—	—	—	—	—	—	Penetrated stony clay for 243 feet; some sand at 106 ft.
14	9	SE	2	Dr	5	106	325	-90	106	Sd	Hn	Dm St	200	
14	10	NE	1	Dg	—	52	349	-46	—	Sd	Hn	Dm St	—	
14	10	NE	2	Sp	—	6	349	0	0	Sd	ST	Dm St	—	Supplies two farms
14	10	SW	3	Dr	5	205	374	-145	—	Sd	Hn	Dm St	—	See chemical analysis. Log incomplete.
14	11	NE	1	Dr	4	41	241	-31	—	Sd gr	Ab	Dm	—	See chemical analysis
14	12	NW	1	Sp	—	—	206	—	0	Sd	ST	Dm St	—	Water piped to fourteen houses and farms along Mount Lehman road in sec.'s 11 and 12.
14	13	SW	1	Sp	—	—	200	—	0	Sd	ST	Dm St	4,800	Water supplies seven farms
14	14	SE	1	Dr	4	53	255	—	44	Gr	Ab	Dm St	—	See chemical analysis
14	15	NE	1	Dr	4	255	253	-185	225	Gr	?	Dm St	—	S . See chemical analysis. Penetrated 135 ft. of marine clay, 20 ft. of sand and 100 ft. of a second marine clay above aquifer.

REPRESENTATIVE OF WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION			WELL NO.	DESCRIPTION OF WELL				PRINCIPAL AQUIFERS		WATER	YIELD			REMARKS
Tp.	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
14	16	NE	1	TH	—	280	472	—	—	--	—	—	--	Penetrated 280 feet of marine clay.
14	21	NE	1	Dr	—	300	470	—	300	Gr	Hn	—	--	Well at Jubilee school
14	21	NW	2	Dg	—	23	33	-18	16	Gr	Hn	Dm St	—	
14	27	SE	1	Dr	2	130	21	+10	130	Sd	?	Dm St	--	Water is sulphurous and hard
16	4	NE	1	Dr	4	114	175	-70	0	Sd	Hn	Dm Ir	—	Irrigates $\frac{1}{2}$ acre of land
16	4	NE	2	Dr	4	100	160	-50	60	Gr	Hn	Dm St	—	
16	4	SE	3	Dr	$1\frac{1}{2}$	73	102	- 4	42	Gr	Hn	Dm St	—	
16	4	SW	4	Dr	5	118	254	-110	12	Gr	Hn	Dm St	--	Penetrated 12 ft. Sumas till and 106 ft. gravel.
16	5	NE	1	Dr	4	106	221	-90	—	Gr	Ab	Dm St	—	
16	5	SE	2	Dr	4	104	220	-85	—	Gr	Ab	Dm Ir	—	Irrigates 8 acres
16	5	NW	3	Dr	8	81	184?	-50	—	Gr	Ab	Dm Ir	—	Dept. of Agriculture well; yields 240 g.p.m.

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION		WELL NO.		DESCRIPTION OF WELL					PRINCIPAL AQUIFERS		WATER YIELD			REMARKS
Tp.	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	6	NE	1	Dg	48	55	195	-50	0	Gr	Ab	Dm St	—	
16	6	NE	2	Dg	30	43	185	-31	0	Gr	Ab	Dm St	—	
16	6	NW	3	Dr	6	36	181	-29	0	Gr	Ab	Dm	—	
16	7	NE	1	Dr	6	82	202	-33	76	Gr	Ab	Dm St	—	6 ft. gravel and 70 ft. Sumas till above aquifer.
16	7	NE	2	Dg	36	43	197	-37	0	Gr	Ab	Dm Ir	—	Can irrigate 2 acres only
16	8	NE	1	Dr	4	80	219	-71	18	Gr	Ab	Dm St	—	
16	8	SW	2	Dr	4	106	206	-60	75	Gr	Ab	Dm St	—	
16	9	SE	1	Dg	40	72	174	-65	30	Gr	Ab	Dm St	—	
16	9	SW	2	Dr	4	94	180	-44	—	Gr	Ab	Dm St	—	
16	9	SW	3	Dr	5	136	218	-46	—	Gr	Ab	Dm St	—	
16	16	NE	1	Dg	42	38	179	-33	0	Sd	Ab	Dm St	—	
16	16	SE	2	Dr	6	90	170	-45	85	Gr	Ab	Dm	—	

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS		WATER	YIELD		REMARKS
Tp.	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	16	SE	3	Dg	36	17	178	-12	6	Gr	Ab	Dm St	—	
16	16	SW	4	Dg	18	76	224	-61	30	Gr	Ab	Dm St	—	Supplies 26 head of stock
16	16	SW	5	Dg	42	36	196	-25	14	Gr	Ab	Dm St	—	
16	16	SW	6	Dr	4	46	185	-34	38	Gr	Ab	Dm St	—	Top aquifer 38 to 46 ft.; test hole encountered a second aquifer at 70 ft.
16	16	NW	7	Dg	36	25	173	-19	—	Sd	Ab	Dm	—	
16	17	NE	1	Dr	4	54	192	-34	50	Gr	Ab	Dm St	—	40 ft. gravel and 10 ft. Sumas till above aquifer.
16	17	SE	2	Dr	6	82	231	-70	63	Gr	Ab	Dm St	—	
16	17	SW	3	Dg	48	35	212	-33	33	Gr	Ab	Dm St	—	30 ft. gravel and 3 ft. Sumas till above aquifer.
16	17	NW	4	Dr	5	112	208	-56	—	Gr	Hn	Dm	300	Well at North Poplar school
16	18	SW	1	Dr	5	138	231	-70	—	Gr	Ab	Dm St	—	Supplies 22 head stock
16	18	NW	2	Dr	6	25	192	-15	0	Gr	Ab	Dm	600	

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION		WELL NO.		DESCRIPTION OF WELL			PRINCIPAL AQUIFERS			WATER		YIELD	REMARKS
Tp.	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	18	NW	3	Dr	4	29	200	-23	0	Gr	Ab	Dm	—	
16	19	SE	1	Dr	10	103	—	-43	93	Sd	Hn	Mn	3,600	Clearbrook well; see chemical analysis
16	19	NW	2	Dr	6	79	200	+ 1	73	Sd	Hn	D	—	Flows at rate of $\frac{1}{2}$ g.p.m.
16	20	NE	1	Dr	6	73	192	-63	—	Gr	Ab	Dm St	—	
16	20	SE	2	Dr	4	80	210	-68	—	Gr	Ab	Dm	—	Well supplies four families
16	20	SE	3	Dr	6	70	216	-35	—	Gr	Ab	Dm St	—	
16	20	SE	4	Dr	4	104	207	-44	—	Gr	Ab	Dm	—	
16	20	NW	5	Dr	4	40	200	-30	0	Gr sd	Ab	Dm Ir	—	Irrigates one acre
16	21	SE	1	Dr	6	74	—	-25	72	Sd	Hn	—	—	
16	21	SW	2	Dr	6	112	—	-52	70	Sd	Hn	—	—	Well at MSA Motors; see chemical analysis
16	22	NE	1	Dg	36	70	212	-65	—	Sd	Hn	Dm St	—	
16	22	NW	2	Sp	—	18	42	-12	—	Sd	Hn	Dm St	—	

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION		WELL NO.		DESCRIPTION OF WELL			PRINCIPAL AQUIFERS			WATER		YIELD		REMARKS
Tp.	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft.)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	22	NW	3	Sp.	—	31	58	-22	—	Sd	?	Dm St	—	
16	23	NW	1	Dr	4	71	225	-59	50	Gr	?	Dm St	480	
16	26	SE	1	Dr	6	140	242	—	—	Gr	?	Dm St	—	
16	26	SW	2	Dg	—	57	212	-51	52	Sd	?	Dm St	—	34 ft. sand and 18 ft. till above aquifer.
16	26	SW	3	Dg	36	45	187	-41	—	Sd	?	Dm St	—	
16	27	SE	1	Dg	36	17	44	-12	—	Sd	?	Dm St	—	
16	28	NE	1	Dg	36	40	171	-20	—	Gr	?	Dm	—	
16	28	SW	2	Dr	4	84	202	-35	—	Gr	Ab	Dm St	—	
16	29	NE	1	Dr	4	133	198	-54	106	Sd	?	Dm St	—	See chemical analysis
16	30	SW	2	Dg	—	40	377	-30	39	Gr	Hn	Dm	—	39 ft. till above aquifer.
16	31	NE	1	Dg	—	16	91	- 6	—	Sd	—	Dm St	—	
16	31	NW	2	Sp	—	—	118	—	—	—	—	—	750	

REPRESENTATIVE WELL RECORDS OF MATSQUI MUNICIPALITY, BRITISH COLUMBIA

LOCATION			WELL NO.	DESCRIPTION OF WELL				PRINCIPAL AQUIFERS			WATER	YIELD		REMARKS
Tp.	Sec.	1/4		Type	Casing diam. (in.)	Depth (ft)	Collar elev. (ft.)	Static level (ft.)	Depth to top (ft.)	Character of material	Formation	Use	Gals./hr.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	33	SE	1	Dg	36	24	146	-10	—	Sd	—	Dm St	—	
16	33	NE	2	Dr	5	75	14	—	—	Sd		St	—	50 ft. silty clay above aquifer; see chemical analysis.
16	35	SW	1	T	4	66	—	—	—	—	—	—	—	Penetrated 15 ft. of Sumas till and 51 ft. of blue clay.
17	12	SW	1	Dr	10	55	16	- 9	37	Sd	GL	Dm	2,400	Well at Naval Station

CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 329

GROUND-WATER RESOURCES OF WEYBURN MAP-AREA SASKATCHEWAN

By
E. Hall

OTTAWA
1960

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UNCONSOLIDATED DEPOSITS

During Pleistocene time a mantle of glacial drift, in places more than 400 feet thick, was deposited over the Weyburn area. Moraine of low relief (Gm)[1] covers more than three quarters of the area. It is composed essentially of till and has a local relief that rarely exceeds 25 feet. Randomly scattered through the till are pockets of silt and sand that were deposited by meltwater from the glacier. These form the aquifers supplying water to most wells in the moraine of low relief. The pockets generally have an areal extent of only a few square feet, and especially when they are at a shallow depth, water levels in wells dug into them show a rapid response to changes in precipitation. There is no surface indication of these pockets of sand and silt, but with sufficient prospecting, one or more can usually be found within a depth of 25 feet that will supply sufficient hard water to serve the needs of a farmhouse and a few head of cattle. On the map are shown the approximate boundaries and depths of larger and deeper aquifers. In general, these will supply greater quantities of water and are less affected by drought conditions, though in many cases the water is too 'alkaline' for human consumption. Outside of these areas there are numerous individual wells supplying abundant water but because of insufficient information it is not possible to outline their aquifers.

Areas of hummocky moraine (Hm)[1] are confined to Moose Mountain and the Missouri Coteau, where the local relief commonly exceeds 100 feet. These areas are composed essentially of till but also contain small pockets of silt and sand, and minor amounts of sand and gravel in the form of kames. The hummocky moraine is dotted with depressions that have no surface drainage so that sloughs and small lakes are formed. Seepage from these bodies of water recharges the numerous springs on the

[1] Letter symbols in parentheses refer to map-legend

lower slopes of the hummocky moraine and also some of the aquifers underlying adjacent lowland areas. Most wells in the hummocky moraine obtain water from the small pockets of silt and sand buried in the till. These pockets can usually be found within 20 feet of the surface although it may be necessary to dig several dry holes before one is located. The deposits of sand and gravel that are, in places, found at the surface of the hummocky moraine are usually not productive aquifers due to the water draining out on adjacent slopes.

There are three major end moraines (Em) within the Weyburn map-area. The largest is the Stoughton moraine which is composed essentially of till. It has ground-water conditions within it that appear to be almost similar to those in the areas of moraine of low relief. The Kisbey moraine contains a high proportion of sand. Over most of its area it is easy to obtain sufficient medium-hard water from depths of less than 40 feet for the needs of 100 to 150 head of cattle. The Oxbow Moraine is composed largely of stratified silt and intercalated till lenses. These sediments are usually too fine grained to form an aquifer and this moraine is not favourable for obtaining ground water from shallow depths.

Eroded moraine (Er) is confined to the Souris River spillway. It is characterized by the numerous boulders visible at the surface and locally by alluvial deposits of sand and gravel. The sand and gravel deposits are rarely more than 15 feet thick but some can supply sufficient soft water for over 50 cattle even during dry years. Because of its low agricultural value, the eroded moraine is sparsely settled and few wells have been dug into it, consequently information is lacking concerning the location and areal extent of individual aquifers.

Areas mapped as kames (K) have a relatively small areal extent, and due to lack of exposures, little is known of their internal composition.

Shallow gravel pits show that at least the surface of some of them consists of sand and gravel. It is suggested that the lower slopes and the immediate vicinity of the base of those known to contain sand and gravel could provide favourable areas in which to attempt to locate ground water at relatively shallow depths.

Outwash (Op) is composed of stratified sand and gravel. Where it is more than a few feet thick it furnishes the most dependable and easily developed water supplies within the map-area. The water obtained is only moderately hard and the water levels are only slightly affected by drought conditions. The most productive outwash area knownis in the vicinity of Auburnton Creek where several wells less than 15 feet deep are each capable of supplying sufficient water for more than 100 head of cattle. There has been little development of ground water from the outwash plains near Lost Horse Hills but it is believed that they could be equally productive. The largest outwash plain in the Weyburn area is that south of Wordsworth. It contains many wells up to 20 feet deep that are capable of supplying water for more than 50 head of cattle but, in places, and especially along its western edge, the sand and gravel is only 1 foot or 2 feet thick and is unproductive. The outwash plain near Osage is the southern edge of an extensive deposit of sand and gravel. Only small amounts of ground water can be obtained from this source in the immediate vicinity of Osage, but near the northern edge of the map-area, where the sand and gravel is known to be at least 20 feet thick, adequate water for individual farm use is obtained by means of sand points.

Glacial-lake deposits (Glb) vary in composition and permeability in the different glacial-lake basins of the Weyburn area. The 160 square miles of the Lake Regina basin that lie along the western boundary of the map-area consist of lacustrine clay that is silty near the edge of the

basin. The relatively impervious clay is up to 20 feet thick over much of the basin and considerably restricts the seepage of precipitation to underlying aquifers, where present. Consequently over much of the Lake Regina basin only small supplies of hard 'alkaline' water may be expected. Within this area the greatest concentration of wells yielding relatively large amounts of water is in tp. 9, rge. 15. Here, a number of wells approximately 25 feet deep, each derive sufficient water for more than 50 head of cattle from glacial sand and gravel beneath the clay. Lake Arcola basin sediments range in composition from stratified sands in the northwest to stratified silts and clays in the eastern part. Except for an area between Arcola and Carlyle, where till is close to the surface, the lake-basin sediments form an excellent aquifer. In the eastern part of the basin the sand aquifer is overlain by 10 to 20 feet of black clay that gradually decreases in thickness toward the west. The sands are known to reach a thickness of 40 feet and wells dug at most places within the basin will yield an abundant supply of medium-hard, clear water. The smaller lake basins within the map-area are not known to contain any large aquifers. Generally, wells in these areas must be dug through the lake sediments and into pockets of silt and sand in the underlying till.

Alluvium (Afp) is present along the upper reaches of Moose Mountain Creek and along Souris River to the southeast of Weyburn. A number of wells on the flood plain of Moose Mountain Creek supply sufficient water for at least 50 cattle. The water is obtained at depths of about 12 feet from beds of sand and gravel. On Souris River the alluvial flood plain consists largely of silts with thin beds of fine-grained sand. Downstream from Roche Percée the alluvium is sandier than it is to the northwest. Wells dug into these deposits are commonly about 15 feet deep and depend on seepage from the river. Only moderate quantities of soft to medium-hard water are obtained. One well drilled into these

deposits near Oxbow, where the alluvium is about 30 feet thick only delivered 2 gallons per minute under test.

Meltwater flowing from the glaciers formed many broad, shallow depressions in the drift that are now commonly occupied by intermittent streams. These meltwater channels commonly contain deposits of sand and gravel, particularly in slip-off slopes on meander bends. The sand and gravel probably rarely exceeds 10 feet in depth but will supply sufficient water for a small farm. These channels also collect and store a certain amount of the precipitation so that recharge conditions to underlying aquifers in the till to depths of approximately 20 feet, are better than they are in adjoining areas. For this reason meltwater channels commonly form the most favourable place to locate water at shallow depths in till areas.

The preglacial channel of the Missouri River was cut to depths of 250 to 400 feet below the present surface of the Weyburn area. Little is known of the ground-water potential of this channel, but at one location in sec. 16, tp. 4, rge. 8, W. 2, at least 17 feet of glacial sand and gravel is present beneath 347 feet of till. A bailer test in this hole produced 12 gallons of water per minute with very little drawdown. The location of the channel as shown on the accompanying map is only approximate and any drilling operationsto locate it should be preceded by a resistivity or seismic survey.

BEDROCK

Riding Mountain Formation

The Riding Mountain formation does not outcrop within the map-area but it is known to underlie the till in much of the northern part. It is more than 1,000 feet thick, consisting of grey to greenish grey shale, in part siliceous. Water is sometimes obtained from fractures in

the upper surface of the formation but only small quantities of highly saline water are likely to be found below the zone of fracturing. Many dry holes have been drilled into the formation and farmers are strongly advised to refrain from the expense of drilling to considerable depths within this material.

Eastend Formation

The Eastend formation lies between the Riding Mountain formation and the Ravenscrag formation, and immediately underlies the till in the 4-to-10-mile-wide belt shown on the map. Its only known outcrops are on Souris River 14 miles southeast of Weyburn and on Roughbark Creek near Halbrite. The formation rarely exceeds 40 feet in thickness and consists principally of fine-grained sands and silts with some shale and thin seams of lignite. Although the Eastend formation is water-bearing, the fineness of the sand makes it difficult to obtain large quantities of water and to maintain the well. No wells are known to be producing water from this source to the east of rge. 13.

Ravenscrag Formation

The Ravenscrag formation overlies the Eastend formation and is the youngest bedrock in the area. It consists of sand, silt, shale, clay, and lignite. The seams of sand and lignite that comprise the aquifers are not thought to be continuous horizons throughout the formation but rather a series of large lens-like deposits. Holes drilled almost anywhere in the Ravenscrag formation can encounter at least one of these aquifers. The water obtained is generally soft due to the presence of sodium carbonate and although usable by both livestock and humans it is unsuitable for irrigation. The water is under hydrostatic pressure and will rise up the hole to such an extent that in places flowing artesian wells are obtained. Water levels in wells in this formation are not affected by prolonged periods of drought. There is little quantitative information available but one well at Bienfait, 150 feet deep,

produces 20 gallons per minute from the Ravenscrag formation. In many places it is possible that production could be increased by deepening wells so that two or more aquifers could be used at the same time.

FIGURE 1

TABLE OF SURFICIAL DEPOSITS

ENVIRONMENTAL DIVISIONS AND DESCRIPTIONS

GEOLOGICAL SURVEY OF CANADA

GROUP OR INTERVAL	GLACIAL DEPOSITS: GLACIAL	GLACIAL DEPOSITS: GLACIO FLUVIAL	GLACIAL DEPOSITS: GLACIO-LACUSTRINE	GLACIAL DEPOSITS: GLACIO MARINE	MARINE DEPOSITS: OFF SHORE	MARINE AND NON-MARINE DEPOSITS: DELTAIC	MARINE AND NON-MARINE DEPOSITS: CHANNEL AND FLOOD PLAIN	MARINE AND NON-MARINE DEPOSITS: SLOPEWASH	MARINE AND NON-MARINE DEPOSITS: WINDBLOWN	MARINE AND NON-MARINE DEPOSITS: SWAMP
SALISH (Post-glacial deposits still being formed; in part overlap Capilano deposits)						Non-marine delta deposits · gravel and sand (50'+)	*FRASER FLOOD PLAIN DEPOSITS* silty clay, clayey silt, silt, sand-silt, and sand (50'+) indistinguishable from underlying Cloverdale sediments	*SLOPEWASH DEPOSITS* silt, sand, gravel (25'), includes fan deposits of similar materials (50'+)		
CAPILANO (Post-Vashon non-glacial deposits no longer being formed, · part contemporaneous with, and in part younger, than Sumas) — SUMAS (Post Vashon glacial deposits related to valley ice)	*SUMAS TILL:* sandy till and stratified drift (60')	*ABBOTSFORD OUTWASH·* recessional outwash including pitted outwash sand and gravel (125'); ice contact gravel and sand containing lenses of till and of glacio-marine deposits (50'+)	Clayey silt, silt, silty clay, and minor sand and gravel (250')	*WHATCOM GLACIO-MARINE DEPOSITS·* marine drift, stony silty clay, clay, silt, minor sand and gravel (300')	*CLOVERDALE SEDIMENTS* clay, silty clay, silt and minor sand, gravel and poorly sorted till-like mixtures (900'+)		*HUNTINGDON GRAVEL* gravel and sand (100'+), underlies Whatcom glacio-marine deposits, in places overlies an older glacio-marine deposit which may be Newton stony clay		*DUNE SAND* windblown sand deposited by westerly winds blowing across Abbotsford outwash (40')	*SWAMP DEPOSITS* peat, muck, and organic clay (60')
VASHON (Deposits of last glaciation of ice-sheet proportions)	*SURREY TILL:* sand, silty till and substratified drift (75)			*NEWTON STONY CLA[Y]* marine drift, poorly sorted till-like mixtures, stony clayey silt, and minor silt, clay, sand and gravel (200'+), in place stratigraphically indistinguishable from Whatcom glacio-marine deposits						
EROSION INTERVAL. CONSIDERABLE RELIEF DEVELOPED ON UNDERLYING DEPOSITS										
PRE-VASHON	GLACIAL. MARINE AND NON-MARINE DEPOSITS. PROBABLY IN A LARGE PART EQUIVALENT TO DEPOSITS OF SEMIAMU, QUADRA AND SEYMOUR GROUPS, FOUND EXPOSED IN AREAS TO THE WEST. EXPOSED ONLY IN DEEP DRILL HOLES. IN THIS AREA									
TERTIARY	SANDSTONE. SILTSTONE. SHALE, CONGLOMERATE. AND MINOR VOLCANIC ROCKS (10,000± FEET)									

PUBLISHED 1960

Note: Numbers in parentheses are maximum thicknesses in feet

To accompany Water Supply Paper No. 328, Ground-Water Resources of Matsqui Municipality, B.C. by E.C. Halstead. Table compiled by J.E. Armstrong.

1

AL DEPOSITS

S AND DESCRIPTIONS

MARINE DEPOSITS	MARINE AND NON-MARINE DEPOSITS				
OFF SHORE	DELTAIC	CHANNEL AND FLOOD PLAIN	SLOPEWASH	WINDBLOWN	SWAMP
	Non-marine delta deposits: gravel and sand (50'+)	*FRASER FLOOD PLAIN DEPOSITS: silty clay, clayey silt, silt, sand-silt, and sand (50'+) indistinguishable from underlying Cloverdale sediments*	*SLOPEWASH DEPOSITS: silt, sand, gravel (25'); includes fan deposits of similar materials (50'+)*		*SWAMP DEPOSITS: peat, muck, and organic clay (60')*
CLOVERDALE SEDIMENTS: clay, silty clay, silt and minor sand, gravel and poorly sorted till-like mixtures (900'+)				*DUNE SAND: windblown sand deposited by westerly winds blowing across Abbotsford outwash (40')*	
	HUNTINGDON GRAVEL: gravel and sand (100'+), underlies Whatcom glacio-marine deposits; in places overlies an older glacio-marine deposit which may be Newton stony clay				

EVELOPED ON UNDERLYING DEPOSITS

UIVALENT TO DEPOSITS OF SEMIAMU, QUADRA AND SEYMOUR GROUPS, FOUND EXPOSED

CKS (10,000± FEET)

PUBLISHED, 1960

To accompany Water Supply Paper No. 328, Ground-Water Resources of Matsqui Municipality, B. C. by E. C. Halstead. Table compiled by J. E. Armstrong.

CANADA.

Figure 1

PART OF SHEET 92G

LEGEND

PLEISTOCENE AND RECENT

POST-GLACIAL

CENOZOIC

SALISH GROUP (9-11)

11 SWAMP DEPOSITS: peat, clayey peat, and peaty clay up to 35 feet thick, in most places resting on silty clay and clayey silt

10 SLOPEWASH DEPOSITS: sand, silty clay, and clay up to 10 feet thick overlying ABBOTSFORD OUTWASH (8)

9 FRASER FLOODPLAIN DEPOSITS: floodplain and channel deposits, silty clay, clayey silt, silt and sand up to 20 feet thick resting on sand; in places where deposits are channeled the ridges are sand and silt and the hollows are silt and clay, ridges vary from 5 to 10 feet in elevation above the hollows

GLACIAL

SUMAS GROUP (5-8)

8 ABBOTSFORD OUTWASH: glacio-fluvial deposits, 8a, recessional outwash, including pitted outwash - sand and gravel up to 125 feet thick, in places overlain by dune sand up to 25 feet thick; 8b, ice contact deposits - gravel and sand containing lenses of till and of glacio-marine clayey silt, 50 feet or more thick

7 GLACIO-LACUSTRINE DEPOSITS: silty clay, clayey silt, silt, fine sand, and minor coarse sand and gravel

6 SUMAS TILL: glacial deposits, 6a, sandy till and substratified drift 5 to 35 feet thick, 6b, sandy till and substratified drift less than 5 feet thick

5 WHATCOM GLACIO-MARINE DEPOSITS: stony silty clay and clayey silt, clay, silt, and sand, 25 to 300 feet thick

POST-GLACIAL AND GLACIAL

(In part younger, in part contemporaneous, and in part older than Sumas Group)

CAPILANO GROUP

4 HUNTINGDON GRAVEL: channel and floodplain deposits, gravel and sand up to 100 feet or more thick

TERTIARY

3 Tertiary sandstone, siltstone, shale, and conglomerate at or within 25 feet of surface. Where bedrock is not at surface it is overlain by glacial and glacio-fluvial deposits

PALAEOZOIC AND MESOZOIC

E-TERTIARY

2 Mesozoic granitic and associated rock types at or within 25 feet of surface

1 ... rocks at or within 25 feet of surface

Geological boundary, mainly gradational

Sand and gravel pits

Geology by J. E. Armstrong, 1953 and 1954

Compilation by J. E. Armstrong, 1958

Main road

Other roads

Electric power line

International boundary

Municipal boundary

Township boundary

Section line and number

Indian Reserve boundary

Stream (position approximate)

Marsh

Contours (interval 100 feet except for ...

Approximate magnetic declination, 23° 19' East

GEOLOGICAL SURVEY OF CANADA

MINES AND TECHNICAL SURVEYS

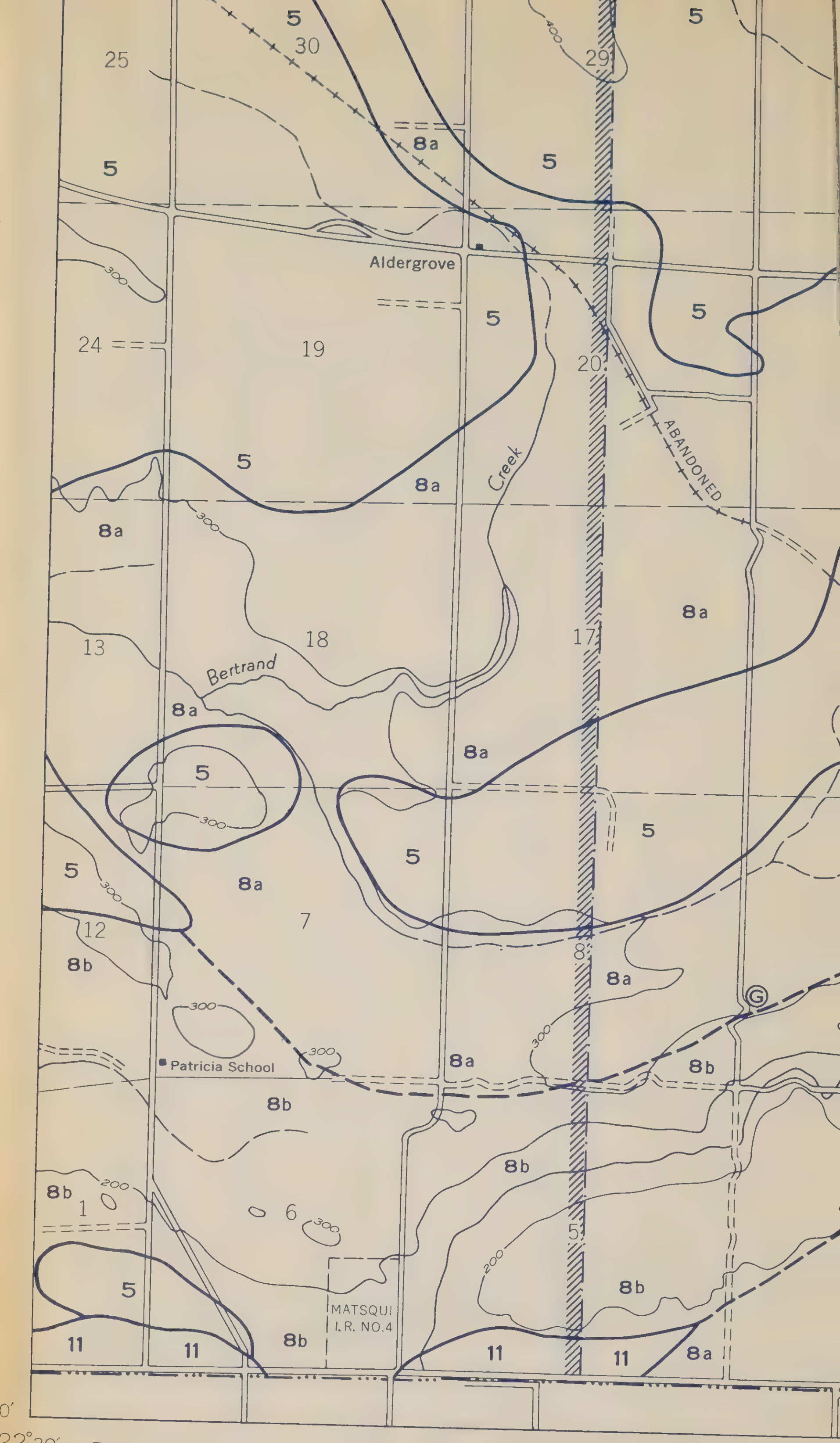
SURFACE DEPOSITS

MATSQUI MUNICIPALITY

NEW WESTMINSTER DISTRICT

BRITISH COLUMBIA

To accompany Water Supply Paper No. 328



PUBLISHED, 1960

LEGEND

NOTE. Wells are numbered clockwise in each section, starting in the upper right hand corner. The upper number is that of the well, the lower number is the depth in feet (within 5 feet) at which water was encountered

X | Water-table wells

● Flowing artesian wells

O Springs

Dry hole

A | Areas in which most of the ground water is obtained from flowing artesian wells. Aquifers at depths of 100 to 500 feet or more are overlain by impermeable fine sands, silts and clay

B | Areas in which most of the ground water is obtained from non-flowing artesian wells. Huntingdon gravel underlies 40 to 300 feet of Whatcom stony clay, at greater depths permeable sediments underlie till

C | Areas in which most of the ground water is obtained from water-table wells. Abbotsford outwash gravel which in places overlies Huntingdon gravel constitutes the principal aquifer. C1 = areas where Sumas till separates the Abbotsford gravel from the Huntingdon gravel

D | Areas of Huntingdon gravel, glacio lacustrine deposits or Abbotsford outwash in which most of the ground water is obtained from shallow water-table wells, sandpoints and springs

E | Areas, of bedrock, in which ground water supply is poor or lacking

Boundary separating ground water areas A, B, C, D and E

Data compiled by E. C. Halstead, 1956, 1957, 1958

Main road

Other roads

Electric power line

International boundary

Municipal boundary

Township boundary

Section line and number

Indian Reserve boundary

Stream (position approximate)

Marsh

Foreshore flats

Contours (interval 100 feet except for 25 foot contours along Fraser River)

Cartography by the Geological Survey of Canada, 1960

Approximate magnetic declination, 23° 30' East

GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

LOCATION AND TYPES OF WELLS, AND GROUND-WATER AREAS

MATSQUI MUNICIPALITY

NEW WESTMINSTER DISTRICT

BRITISH COLUMBIA

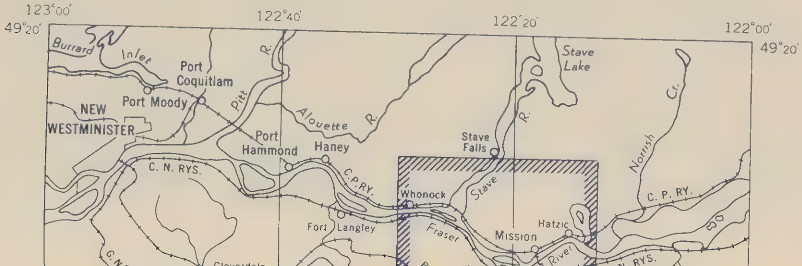
Scale: One Inch to ½ Mile = $\frac{1}{31,680}$

Miles

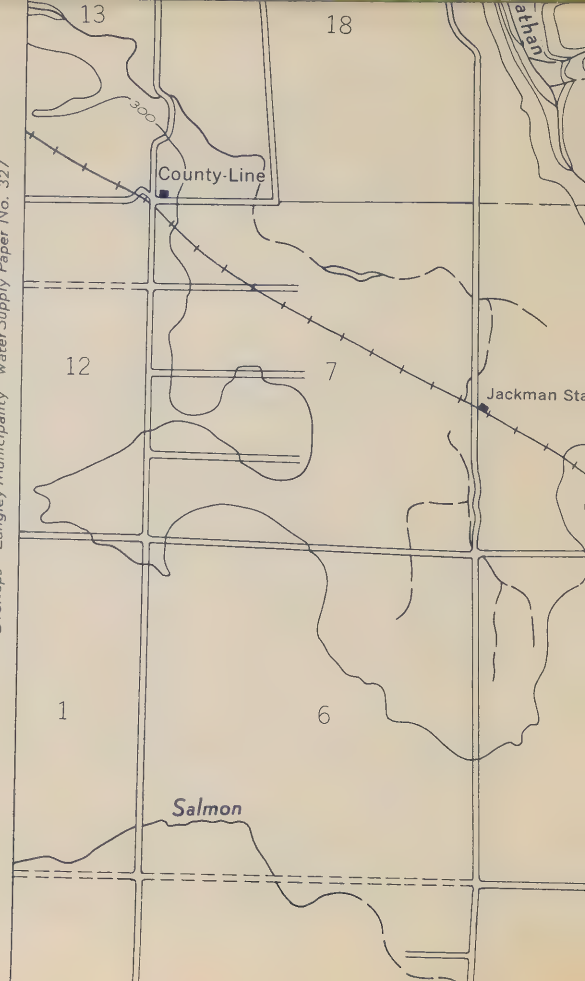
Main road . . . .
Other roads . . . .
Electric power line . . . .
International boundary . . . .
Municipal boundary . . . .
Township boundary . . . .
Section line and number 6
Indian Reserve boundary . . . .
Stream (position approximate) . . . .
Marsh . . . .
Foreshore flats . . . .
Contours (interval 100 feet except for
25 foot contours along Fraser River) 500

Cartography by the Geological Survey of Canada, 1960

Approximate magnetic declination, 23° 10' East



Overlaps "Langley Municipality" Water Supply Paper No. 327



LEGEND

NOTE. Wells are numbered serially in each section. The upper number is that of the well, the lower number is the depth in feet (within 5 feet) at which water was encountered.

- × Free non-artesian wells, includes water-table wells
- ● Flowing artesian wells
- ○ Non-flowing artesian wells
- Springs
- Dry hole
- A Areas in which most of the ground water is obtained from non-artesian wells
- B Areas in which most of the ground water is obtained from flowing artesian wells and springs
- C Areas in which most of the ground water is obtained from non-flowing artesian wells

Boundary separating ground water areas A, B and C

Contours of water table in areas of free ground-water reservoirs — 175

Data compiled by E. C. Halstead, 1954, 1955

Main road
Other roads
Electric power line
International boundary
Municipality boundary
Township boundary
Section line and number — 6
Indian Reserve boundary
Stream (position approximate)
Marsh
Tidal flat
Contours (interval 100 feet except for 25 and 50 foot contours in Langley Lowland and along Fraser River)

Approximate magnetic declination, 23° 24' East

Cartography by Geological Cartography Unit, 1958

INDEX MAP

CANADA
DEPARTMENT
OF
MINES AND TECHNICAL SURVEYS
GEOLOGICAL SURVEY OF CANADA

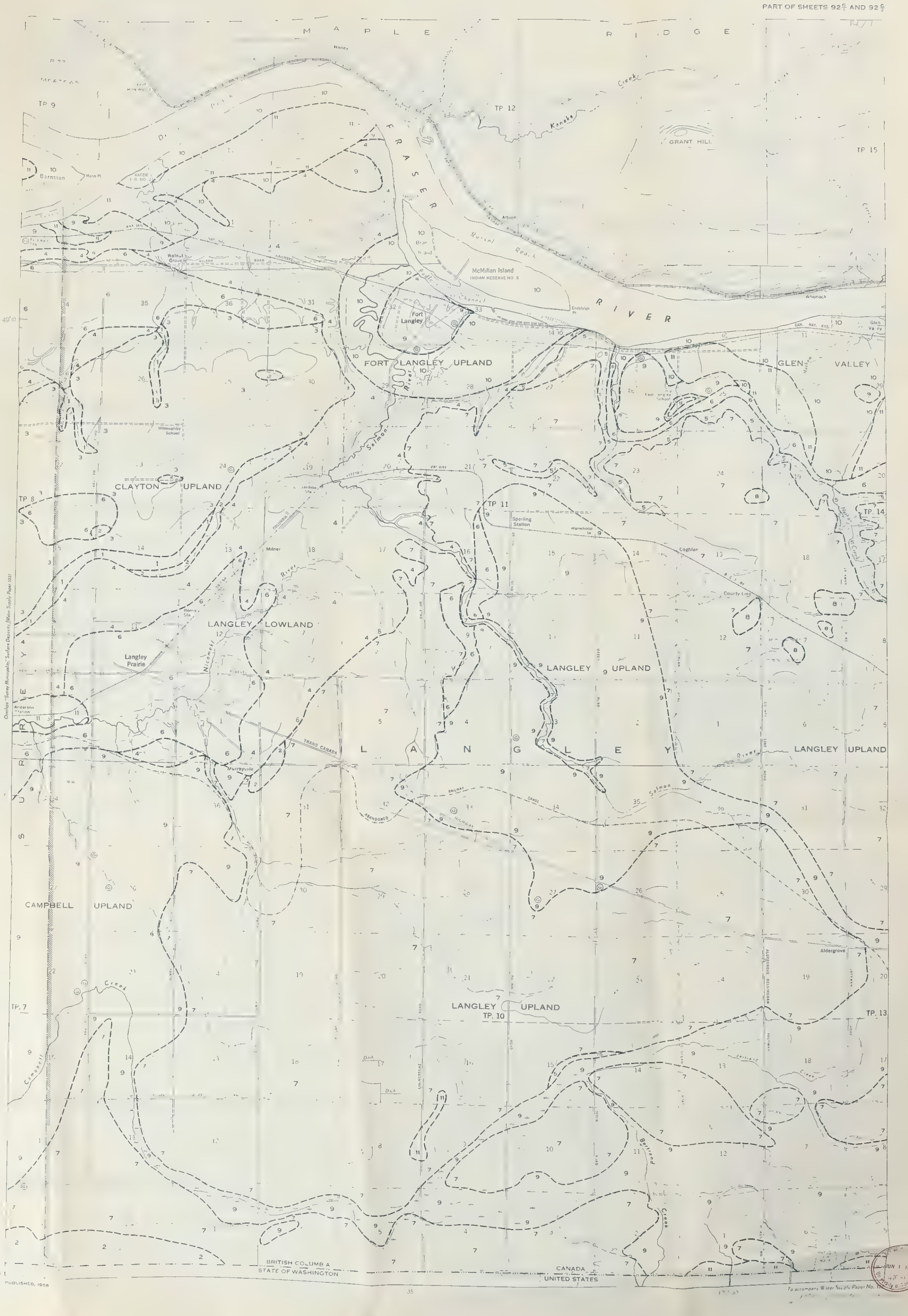
LOCATION AND TYPES OF WELLS, AND GROUND WATER AREAS

LANGLEY MUNICIPALITY

NEW WESTMINSTER DISTRICT
BRITISH COLUMBIA

Scale: One Inch to ½ Mile = $\frac{1}{31,680}$

Miles



LEGEND

QUATERNARY
PLEISTOCENE AND RECENT

POST-GLACIAL

SALISH GROUP

11 SWAMP DEPOSITS peat up to 35 feet thick, resting on silty clay and clayey silt in most places

10 FRASER FLOODPLAIN DEPOSITS, floodplain and channel deposits silty clay, clayey silt, silt and sand at least 50 feet thick, may be much thicker as cannot separate from underlying CLOVERDALE SEDIMENTS (4) in places

GLACIAL

SUMAS GROUP

9 ABBOTSFORD OUTWASH, glacio-fluvial deposits recessional outwash gravel and sand up to 125 feet thick, ice contact deposits consisting of gravel, sand, and lenses of till and glacio-marine silty clay

8 SUMAS TILL, glacial deposits sandy till and minor substratified drift up to 15 feet thick

7 WHATCOM GLACIO-MARINE DEPOSITS, stony clayey silt and silty clay, clay, silt, and sand 25 to 300 feet thick, cannot be separated from NEWTON STONY CLAY (3) in places and deposits mapped as one or the other depending on geographical location and association with other deposits

CENOZOIC

POST-GLACIAL AND GLACIAL
(In part younger, in part contemporaneous, in part older than Capilano Group)

CAPILANO GROUP

6 SUNNYSIDE SAND, raised littoral and beach deposits medium to coarse sand and minor gravel, 3 to 25 feet thick Some slopewash sands of SALISH GROUP (10, 11) included here

5 HUNTINGDON GRAVEL, channel and floodplain deposits, sand and gravel up to 100 feet thick. Some pre-VASHON gravels may be included here

4 CLOVERDALE SEDIMENTS, marine deposits silty clay, clayey silt, silt, clay, minor sand, gravel, and poorly sorted till-like mixtures (marine slopewash) up to 900 feet thick

GLACIAL AND INTERGLACIAL

VASHON GROUP

3 NEWTON STONY CLAY, glacio-marine deposits stony clayey silt, and poorly sorted till-like mixtures, minor clayey silt, silty clay, and sand up to 200 feet thick, covered throughout much of the area by a thin mantle of CAPILANO GROUP (4-6) gravel and minor sand deposited as spits, bars, beaches, and wave-washed lag gravel

2 SURREY TILL, glacial deposits sandy to silty till and minor sub-stratified drift up to 75 feet thick but generally less than 25 feet Mantled by a thin veneer of gravel and sand similar to that mantling 3

PRE-VASHON

1 PRE-SURREY TILL DEPOSITS, UNDIVIDED, mainly interglacial marine and non-marine, minor glacial deposits sand, gravel, silt and clay up to several hundred feet thick. Known glacial deposits not exposed

Geological boundary, mainly gradational

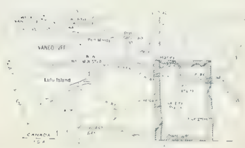
Sand and gravel pits

Geology by J. E. Armstrong, 1952 and 1953
Compilation by J. E. Armstrong, 1956

Main road
Other roads
Electric power line
International boundary
Municipality boundary
Township boundary
Section line and number 6
Indian Reserve boundary
Stream (position approximate)
Marsh
Tidal flat
Contours (interval 100 feet except for 25 and 50 feet contours in Langley Lowland and along Fraser River) 500

Approximate magnetic declination, 23° 24' East

Cartography by Geological Cartography Unit, 1958



INDEX MAP

CANADA
DEPARTMENT
OF
MINES AND TECHNICAL SURVEYS
GEOLOGICAL SURVEY OF CANADA

SURFACE DEPOSITS

LANGLEY MUNICIPALITY

NEW WESTMINSTER DISTRICT
BRITISH COLUMBIA

Scale: One Inch to 1/2 Mile = 1/31,680

PUBLISHED, 1958

To accompany Water Supply Paper No.

TABLE OF SURFICIAL DEPOSITS

GEOLOGICAL SURVEY OF CANADA

ENVIRONMENTAL DIVISIONS AND DESCRIPTIONS

GROUP	GLACIAL DEPOSITS				MARINE DEPOSITS	MARINE AND NON-MARINE DEPOSITS		NON-MARINE DEPOSITS	
	GLACIAL	GLACIO-FLUVIAL	GLACIO-LACUSTRINE	GLACIO-MARINE	OFF SHORE	SHORE	ESTUARINE AND DELTAIC	CHANNEL AND FLOODPLAIN	SWAMP
SALISH (Post-glacial deposits still being formed, in part overlap Capilano deposits)								FRASER FLOODPLAIN DEPOSITS, silt, silty clay, clayey silt, sandy silt, and sand (50+, may be much thicker, in places cannot separate Cloverdale Sediments) STREAM DEPOSITS, silt, silty clay, organic clay, and sand deposited by lowland streams (25+), gravel and sand deposited by mountain streams (50+)	
CAPILANO ([illegible] Vashon non-glacial deposits no longer being formed In part [illegible], in part contemporaneous, in part younger than Sumas) SUMAS (Post-Vashon glacial deposits related to valley ice)	SUMAS TILL; sandy till and minor substratified drift (15+)	ABBOTSFORD OUTWASH, recessional outwash sand and gravel (125); ice contact deposits, gravel, sand, and lenses of till and glacio-marine deposits (50+)		WHATCOM GLACIO-MARINE DEPOSITS (marine drift), stony clayey silt, stony silty clay, clay, silt, and minor sand and gravel (300)	CLOVERDALE SEDIMENTS, silty clay, silt, clay, and minor sand, gravel, and poorly sorted till-like mixtures (900+)	BOSE GRAVEL, gravel and minor sand as spits, bars, beaches, etc., and as wave-washed lag gravel veneers (25) SUNNYSIDE SAND, littoral and beach sand (25)		HUNTINGDON GRAVEL gravel and sand (100+) Underlies Whatcom glacio-marine depos	Peat and muck (35)
VASHON (Deposits of last glaciation of continental ice-sheet proportion)	SURREY TILL, sandy to silty till and substratified drift (75)	MARYHILL OUTWASH, advance outwash gravel, sand, and minor till lenses (200)		NEWTON STONY CLAY (marine drift), poorly sorted till-like mixtures, stony clayey silt, and minor silt, clay, sand and gravel (200+)					
EROSION INTERVAL, CONSIDERABLE RELIEF DEVELOPED ON UNDERLYING DEPOSITS									
SEMIAMU (Deposits related to glaciation, missing in much of area)	SEMIAMU TILL, sandy to silty till and substratified drift (60)	SEMIAMU SEDIMENTS, gravel and sand (25+)	clay, silt, varve-like clay and silt (150+)						
EROSION INTERVAL, CONSIDERABLE RELIEF DEVELOPED ON UNDERLYING DEPOSITS									
QUADRA (Intertill, probably interglacial sediments)							COLEBROOK GRAVEL, gravel and deltaic, floodplain and channel depc NICOMEKL SILT, sand, silt, and minor gravel, at least in part marine (110) STREAM DEPOSITS, sand, silt, clay, and minor gravel lowland areas, gravel, sand, silt, and minor silty clay and clay in mountainous areas (250+) In part marine deltaic deposits	POINT GREY BEDS, sand silt, and peat (60), forms part of stream deposits	
SEYMOUR (Deposits related to glaciation)	SEYMOUR TILL, silty to clayey till and substratified drift (60)	LYNN OUTWASH; gravel and sand (25+)	SISTERS VARVED CLAY, varve-like clay, silt, and sand (500+)	GLACIO-MARINE DEPOSITS, indicated in drill holes. Age uncertain					
	CLAY, SILT, SAND, GRAVEL, TILL AND GLACIO-MARINE DEPOSITS, PROBABLY GLACIAL INTERGLACIAL, AND PRE-GLACIAL ORIGIN, EXPOSED ONLY IN DRILL-HOLES (1000+ FEET)								
TERTIARY	SANDSTONE SILTSTONE, SHALE, CONGLOMERATE, AND MINOR VOLCANIC ROCKS (10,000± FEET)								
PRE-TERTIARY	GRANITIC AND ASSOCIATED ROCK TYPES								

Note Numbers in parentheses are maximum thicknesses in feet

To accompany Water Supply Paper 327, Langley Municipality, B. C., by J. E. Armstrong

CANADA
DEPARTMENT
OF
MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

LEGEND

SURFICIAL DEPOSITS

CENOZOIC

QUATERNARY

RECENT

7 — ALLUVIUM
Clay, silt, sand, and gravel

PLEISTOCENE

6 — CHANNEL AND SPILLWAY DEPOSITS
Poorly sorted sand and coarse gravel; includes alluvium in Souris Valley

5 — DELTA AND ALLUVIAL FANS
Fine gravel and sand above 1,250 feet, coarse sand and medium to fine pebble-gravel below 1,250 feet

4 — LAKE DEPOSITS
Silt, sand and clay ... includes some sand b...

3 — ICE CONTACT STRATIFIED DRIFT
Sand and gravel; includes some outwash

2 — END MORAINE
Sandy silty till; relief ... feet

1 — GROUND MORAINE
Sandy silty till; relief under ... feet

Exposure of reworked Tertiary gravel ... x

Exposure of Tertiary gravel

BEDROCK FORMATIONS

The Upper Cretaceous, Riding Mountain formation of grey and greenish, siliceous shale underlies the unconsolidated deposits.

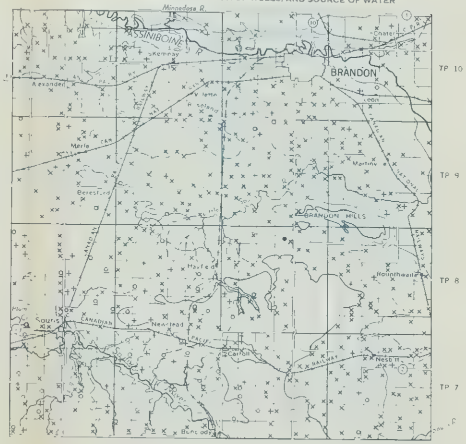
Geological boundary (approximate)

Strand lines and scarps

Surficial Geology by J. A. Elson, 1952, 1953

FIGURE 1
MAP SHOWING SURFICIAL GEOLOGY

FIGURE 2
MAP SHOWING TOPOGRAPHY, LOCATION OF WELLS, AND SOURCE OF WATER



LEGEND

WELL, Class 1 Artesian, water rises above the ground surface

WELL, Class 2 Sub-artesian, the water is under pressure but does not rise above the ground surface

WELL, Class 3 Non-artesian, the water does not rise above the level of the water table

WELL, Unclassified or insufficient information

Note: A dash under a symbol indicates that the well is in bedrock.

Main highway

Other roads

Railway

Contour (interval 100 feet)

Depression contour

Cartography by the Geological Cartography Unit, 1958

TOWNSHIPS 7-10, RANGES 18-21

WEST OF PRINCIPAL MERIDIAN

MANITOBA

Scale: 1 Inch to 4 Miles

4 0 4 8 12

To accompany Water Suppl. Paper ..., by ... Halstead

CANADA
DEPARTMENT
OF
MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

LEGEND

SURFICIAL DEPOSITS

CENOZOIC

QUATERNARY

RECENT AND LATE PLEISTOCENE

ALLUVIUM

8 | Sandy silt and gravel in Pembina Valley, clayey silt east of Pembina Mountains

LAKE DEPOSITS

7 | Mostly sand (some wind-blown), small areas of silt and clay

WATERWORKED DRIFT

6 | Concentrate of sand, gravel and boulders (includes some areas of bare rock)

PLEISTOCENE

OUTWASH OR EOLIAN

5 | Clayey silt

OUTWASH

4 | Gravel in Pembina Valley and near Cardinal; elsewhere mainly sand, silt and clay

ICE-CONTACT STRATIFIED DRIFT

3 | Variably sorted sand and gravel

END MORAINE

2 | Sandy till and minor stratified drift, 2a, washboard moraine deposited from ice moving from the northwest, 2b, moraine deposited from ice moving from the north

GROUND MORAINE

1 | Till (sandy and silty at surface)

BEDROCK FORMATIONS

Upper Cretaceous shales underlie the surface deposits. Riding Mountain formation underlies the part of the area west of Pembina escarpment, and Vermilion River formation outcrops along the escarpment and in Pembina River valley.

Geological boundary (approximate, ...)

Drumlinoid (generally bedrock-covered)

Morainic ridges

Beach bars of glacial Lake Agassiz

Scarps along rivers and strand lines, and Manitoba Escarpment

Surficial Geology by J. A. Elson, 1951

FIGURE 1
MAP SHOWING SURFICIAL GEOLOGY

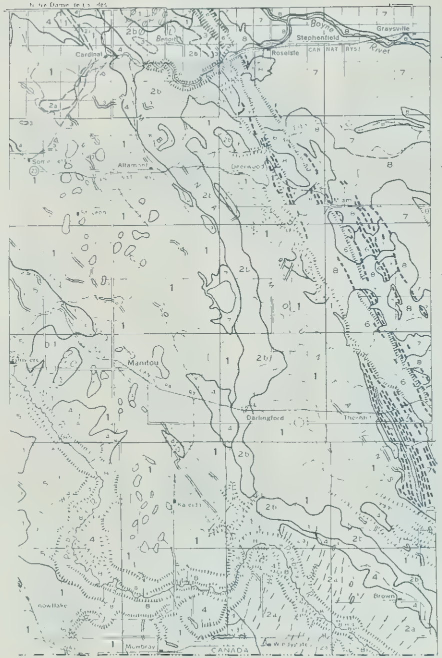
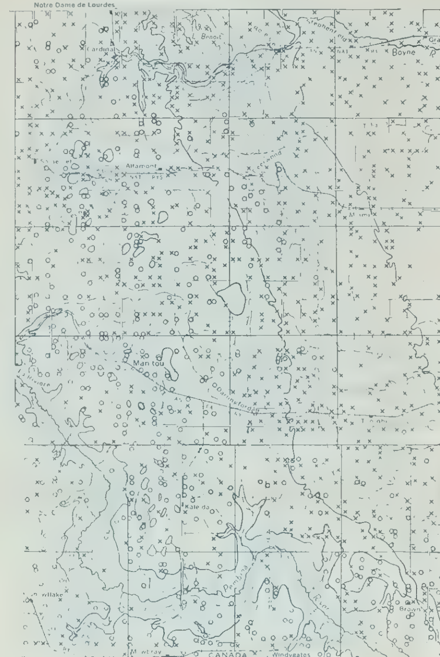


FIGURE 2
MAP SHOWING TOPOGRAPHY, LOCATION OF WELLS AND SOURCE OF WATER



LEGEND

x | WELL: producing from unconsolidated deposits

o | WELL: producing from RIDING MOUNTAIN FORMATION or VERMILION RIVER FORMATION

Main highway

Other roads

Railway

Contour (interval 100 feet)

Depression contour

Cartography by the Geological Cartography Unit, 1958

TOWNSHIPS 1-6, RANGES 6-9

WEST OF PRINCIPAL MERIDIAN

MANITOBA

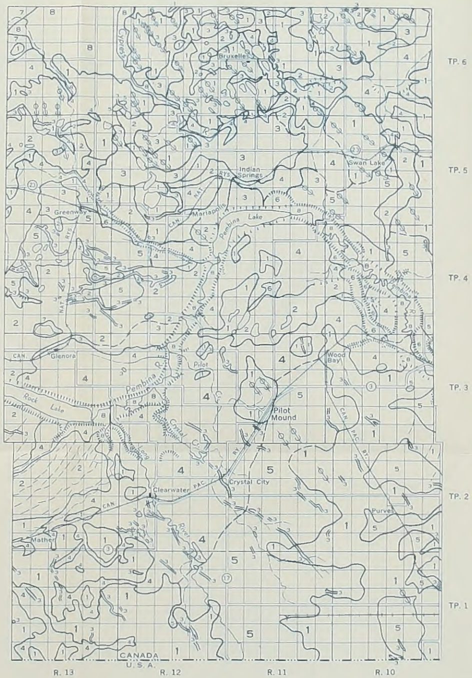
Scale: 1 Inch to 4 Miles

To accompany Water Supply

CANADA
DEPARTMENT
OF
MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

FIGURE 1
MAP SHOWING SURFICIAL GEOLOGY



LEGEND

SURFICIAL DEPOSITS

CENOZOIC

QUATERNARY

RECENT AND LATE PLEISTOCENE

ALLUVIUM

8 — Poorly sorted silt, sand, gravel; minor clay

LAKE DEPOSITS

7 — Mainly sand, minor clay

WATERWORKED DRIFT

6 — Concentrate of sand, gravel, boulders, (includes some areas of bare rock)

PLEISTOCENE

OUTWASH OR EOLIAN

5 — Clayey silt

OUTWASH

4 — Sand, gravel, and minor silt

ICE-CONTACT STRATIFIED DRIFT

3 — Variably sorted sand and gravel

END MORAINE

2 — Sandy till and minor stratified drift

GROUND MORAINE

1 — Till (sandy and silty at surface)

BEDROCK FORMATIONS

The Upper Cretaceous, Riding Mountain formation of grey and greenish, siliceous shale underlies the area.

Geological boundary (approximate, assumed)

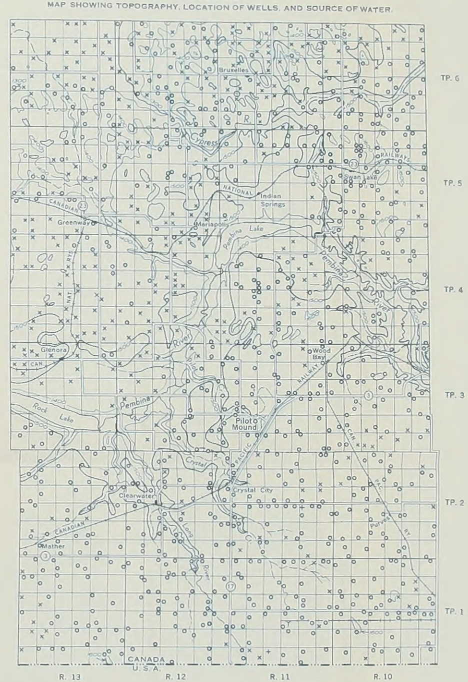
Drumlinoid (generally bedrock-cored)

Morainic ridges

Scarps along rivers and strand lines, and Manitoba escarpment

Surficial Geology by J. A. Elson, 1951

FIGURE 2
MAP SHOWING TOPOGRAPHY, LOCATION OF WELLS, AND SOURCE OF WATER



LEGEND

× — WELL: producing from unconsolidated deposits

o — WELL: producing from RIDING MOUNTAIN FORMATION

+ — WELL: producing from unknown source

Main highway

Other roads

Railway

Contours (interval 100 feet)

Cartography by the Geological Cartography Unit, 1958

TOWNSHIPS 1-6, RANGES 10-13

WEST OF PRINCIPAL MERIDIAN

MANITOBA

Scale: 1 Inch to 4 Miles

4 0 4 8 12

CANADA GEOLOGICAL SURVEY

To accompany Water Supply Paper 325, "Pilot Mound Area," by E. C. Halstead

GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

SHEET 62 E

LEGEND

QUATERNARY
PLEISTOCENE AND RECENT

Afp — Alluvial flood plain: silt and clay with lenses of sand and gravel

Glb — Glacial lake basin: sand, silt, and clay

Op — Outwash plain: mainly sand and gravel

K — Kame, kame-esker complex: sand and gravel with some till

Er — Eroded moraine: till characterized by a surface concentration of boulders and locally covered by a thin veneer of sand and gravel

Em — End moraine: till and stratified silt and sand

Hm — Hummocky moraine: till; minor amounts of sand and gravel

Gm — Ground moraine (of low relief): till containing small lenses of silt and sand

CENOZOIC

TERTIARY
PALEOCENE

RAVENSCRAG FORMATION: sand, silt, shale, clay, and lignite

CRETACEOUS
UPPER CRETACEOUS

EASTEND FORMATION: yellowish sands, silts, grey shale, thin seams of lignite

RIDING MOUNTAIN FORMATION: grey and greenish grey shale, siliceous shale

MESOZOIC

Pleistocene geology modified from "Glacial Geology of Moose Mountain Area," by E. A. Christiansen; Saskatchewan Dept. of Mineral Resources, 1956

Location of preglacial Missouri River after a map published by Meneley, Christiansen, and Kupsch, University of Saskatchewan. Modified on the basis of resistivity work carried out by the Saskatchewan Research Council, and drilling by the Department of Public Works for the Geological Survey of Canada

Surface geological boundary (defined, assumed)
Subsurface geological boundary (assumed)
Spillway
Meltwater channel
Buried preglacial channel (approximate, assumed)
Boundary of aquifer (assumed) with depth in feet — 30-50

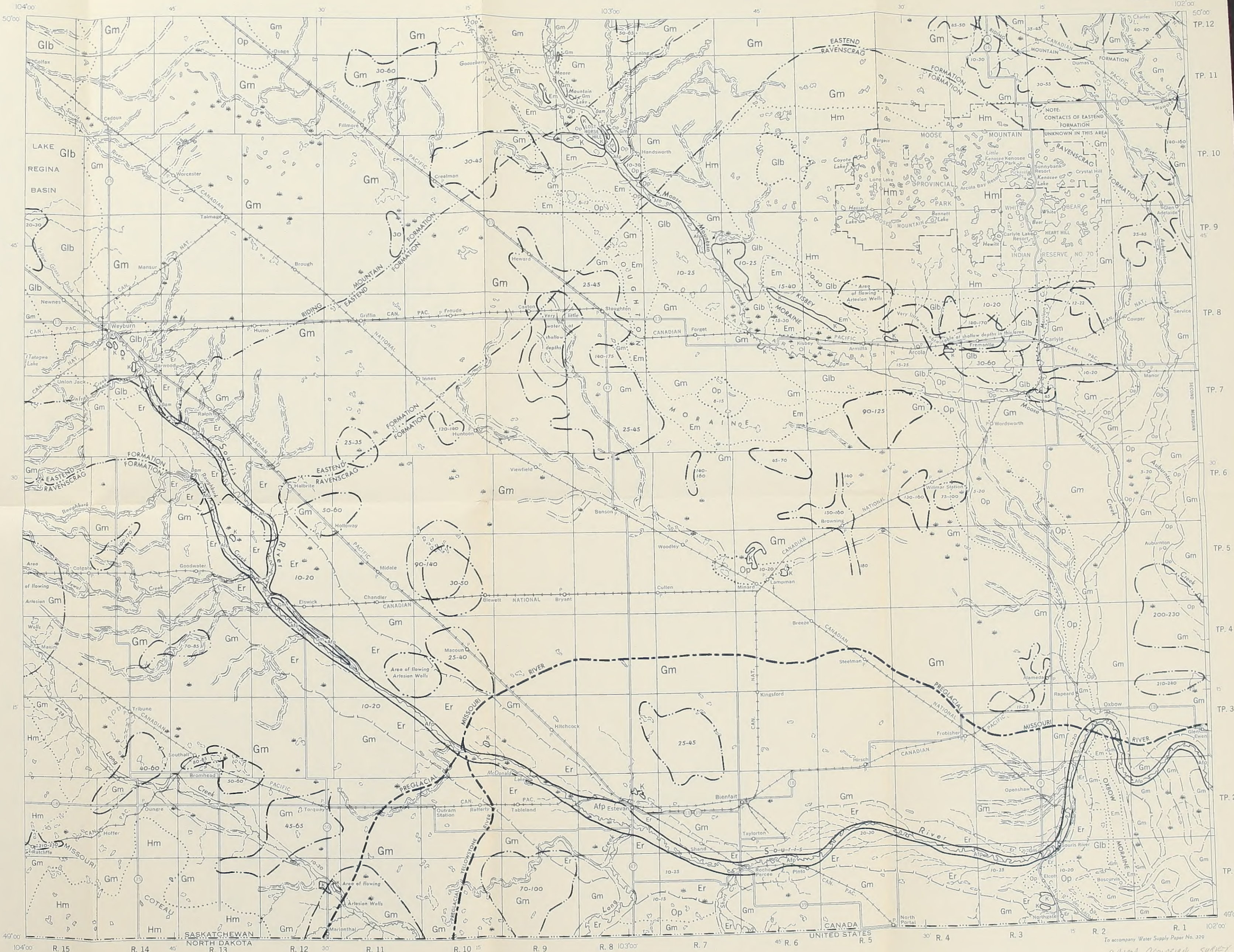
Ground-water geology B. R. McKay, et. al. 1935; E. Hall, 1958, 1959

Main highway
Roads
Railway
International boundary
Township boundary
Provincial Park boundary
Indian Reserve boundary
Post Office
Intermittent lake and stream
Marsh

Cartography by the Geological Survey of Canada, 1961

Approximate magnetic declination, 14° 46' East

Air photographs covering this area may be obtained through the National Air Photographic Library, Topographical Survey, Ottawa



PUBLISHED 1961

To accompany Water Supply Paper No. 329

GROUND-WATER GEOLOGY
SHOWING LOCATION AND EXTENT OF AQUIFERS, AND SURFICIAL DEPOSITS

WEYBURN

WEST OF SECOND MERIDIAN
SASKATCHEWAN

Scale: One Inch to Four Miles = $\frac{1}{253,440}$
Miles